SCIENTIFIC AMERICAN MONTHLY

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THE BALLISTICS OF VOLCANOES—ERUPTION OF SAKURA-JIMA, JAPAN. (SEE PAGE 292)

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THE MYSTERY OF MAYONNAISE.

THERE is no operation of the cuisine that causes the young housewife more apprehension than that of making mayonnaise. She may follow cook book instructions with utmost fidelity, and yet fail. She may do the work under the very eyes of an expert with no better results. There seems to be something uncanny about it. It calls for a mysterious something that cannot be acquired from printed directions or even personal instructions; and yet those who have the knack of making mayonnaise can produce it repeatedly without failure. They seem absolutely unconcerned and even careless in the way in which they mix the ingredients. We know of certain skilled chefs who do the stirring with the hand instead of a fork.

A light is thrown on the mystery of the operation by Professor Bancroft's article on "Bubbles, Drops and Grains," which appears on another page. The chemist recognizes mayonnaise as merely an emulsion of oil in water—a structure of microscopic drops of olive oil, coated with a thin film of white of egg and suspended in water.

The problem of making emulsions successfully has given trouble not only to the housewife, but to the pharmacist as well. Recently, however, manufacturing chemists have devised machines for producing emulsions. At first it was thought that it was merely necessary to agitate a mixture of oil and water in the presence of some colloidal agent in order to produce an emulsion. But when shaking machines were devised for this purpose they failed to produce emulsions. Then it was discovered that the shaking must not be continuous. It is necessary to give the mix a short period of rest, after which a little further shaking forms a successful emulsion. This throws a light on the mayonnaise problem. The usual directions are to add the oil drop by drop which usually results in frequent interruptions of the stirring, which is just what is needed in order to produce a successful emulsion. There are some experts, however, who will mix all the ingredients together and beat them up, after which they will let the material stand for awhile and then with a few strokes of the fork turn it into a successful mayonnaise. The mystery then of making mayonnaise is apparently psychological. The novice approaches the task with fear and trembling and does the work nervously, whereas the expert is much more leisurely and unconsciously puts in the necessary periods of rest.

While Dr. Bancroft does not claim to have tried out this theory himself, he offers it as a probable solution of the mystery. The problem which confronts the housewife is certainly similar to if not the same as that which has confronted the pharmacists and the manufacturing chemist. If this indeed be the solution of the mayonnaise mystery it furnishes us with another example of the far-reaching influences of scientific research.

PROJECTILES *FROM* THE MOON.

POPULAR interest in Dr. Goddard's rocket for reaching high altitudes were excited by the claim that this projectile could actually be made to travel to the moon and there flash a signal which would show that it had completed its journey. There is something romantic in the thought of crossing the intervening hundreds of thousands of miles to the faithful satellite that is our only close companion in the infinite reaches of space. To be sure there would be little if any astronomical value in such an accomplishment. It would serve merely as a demonstration of the power of man to overcome seemingly insurmountable handicaps. But interesting as the feat would be from this point of view, would we be doing anything more than the moon has been doing for millions of years.

According to Emile Bélot, Chief Engineer of Manufactures under the French Government, whose article appears on the following page, the meteorites which bombard the earth are projectiles shot from the moon. The formation of the moon's surface with its enormous yawning craters has given rise to many theories, but M. Bélot clings to the theory that they are of volcanic origin. He is an authority on the subject, having made a careful study of terrestrial volcanoes and the conditions which produce them. To demonstrate his theories he has constructed a working model of a volcanic region with which he is actually able to produce volcanic eruptions on a miniature scale. His model also throws light upon the peculiar crater formations of the moon which differ from those on the earth mainly in degree. He theorizes on the vast lunar eruption and the enormous amount of material they must have ejected. Owing to the lower gravity of the moon and its absence of any atmosphere, this material was hurled far out into space and might easily have escaped from the moon's attraction. It is these particles or volcanic projectiles, according to M. Bélot, which the earth encounters in its swing around the sun, and which fall to our surface as meteorites. These are not to be confused with the "shooting stars" and the meteoric showers which follow the orbits of comets and undoubtedly are of comet origin. He shows that meteorites are not of terrestrial origin and might have come either from our own moon or from the satellites of other planets. If we could identify them they would tell a wonderful story. Imagine the interest in a collection of actual samples of the substance of the satellites ranging from our own moon to distant Triton, the satellite that swings around the remote planet Neptune!

While we may some day be able to send samples of our handicraft to neighboring satellites, it is possible that these satellites have long been sending us samples of themselves. After all our isolation in space may not be quite so real as we had imagined it.

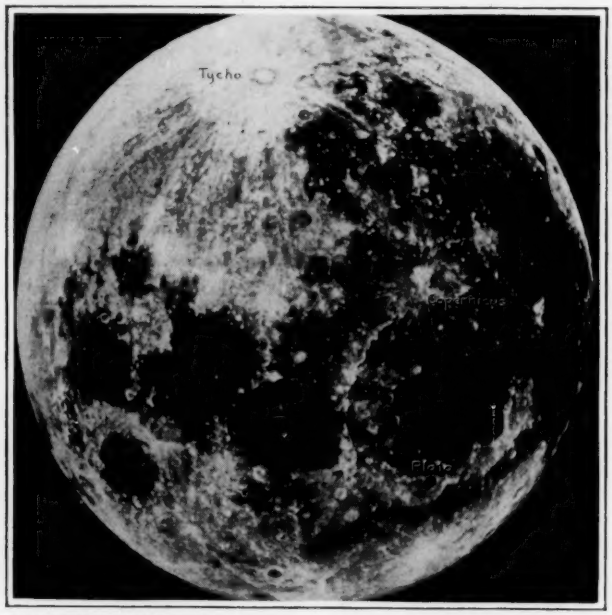
The Ballistics of Volcanoes*

Volcanic Action in the Earth, the Moon, the Universe, and the Laboratory

By Émile Belot, Chief Engineer of Mauufactures under the French Government

THIS time a year ago the big Berthas were circling the Sorbonne with their shells, striking now at the temples of Heaven and now at those of Science. Today, their proud heads are diminished and I mention them but to serve as an introduction to the vast subject of volcanic action, whose extent is far from being generally known or even suspected; there is a victory of mind over matter in the very fact that this colossal engine of scientific barbarism can thus be made to assist in the perfecting of our knowledge in the peaceful domain of Science.

What then is the nature of a "super-gun"? It is a gigantic tube directed towards the sky just as are the volcanic chimneys of volcanoes. At the base of the tube, inside the bore of the cannon, the deflagration of the powder imparts to the gases and vapors a pressure of several thousand atmospheres; in the same way at the base of volcanic chimneys the internal heat of the earth imparts to various fluids a formidable expulsive power. At the instant when the gun is fired there issues from its mouth extending to a short distance a banner of smoke and flame, while the shell is shot to a great distance because of its great density and of its carefully designed form. Likewise when a volcano explodes there is seen a column of smoke and fire from which there are projected volcanic bombs and fragments of rock. The colmun of fumes which rose from the crater of Krakatoa was projected to a height of 27 km., but as a general thing the explosive smoke plumes of volcanoes are not more than 8 or 10 km. high. Thus we see that if there is a resemblance between the form of the super-gun and the volcano there is even more similarity not to say identity of action between them.



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THE FULL MOON. NOTE THE STREAKS RADIATING FROM TYCHO AND COPERNICUS

Let us now examine a pecularity with respect to the firing of the Berthas, which was unfortunately of only too much service to our enemies, and which it is necessary to bear in mind in order to comprehend the wide extent of the volcanic domain. At a height of about 30 km. the shells of the big Berthas reached an atmospheric region where the pressure of 760 mm. which the mercury exhibits at the surface of the earth, is reduced to 1 mm. at the outside—this is as much as to say that the resistance of the air has practically ceased to exist, and the shell has no further trouble, fairly devouring space and lengthening its trajectory. Without this favorable circumstance our enemies would have found it difficult to reach Paris from a distance of 120 km.

The question of the possible range of volcanic bombs is governed by the same principle, and we shall first discuss the problem of the external balistics of volcanic products, and shall speak later of the internal ballistics, which are far more complicated, because they are the result of manifold actions within the bosom of the crust of the earth.

THE EXTERNAL BALLISTICS OF VOLCANOES.

Let us first inquire what becomes of the volcanic matters projected outside the volcano. The first thing they do is to erect the external volcanic cone, but all those volcanic matters which fall within the crater are projected anew, together with the walls of the crater, which thus forms a cup shaped opening. Upon our earth the craters of volcanoes are only a few hundred meters in depth, while upon the moon they are sometimes as much as 4 or 5 km. deep: upon the earth only three carters (Kamschatka, Japan, Philippine Islands) exist which are as much as 20 km. in diameter, while in general the diameter is less than 5 km.; the lake of lava upon Mt. Kilaue, Hawaii, is only 3,200 meters wide. Upon the moon, on the contrary, many craters are as much as 100 km. wide (Theophilus) and sometimes 150 km. (Petavus). We must first explain the reason for this great difference of dimensions upon the earth and upon the moon.

The great American astronomer, Pickering,[1] says upon this subject:

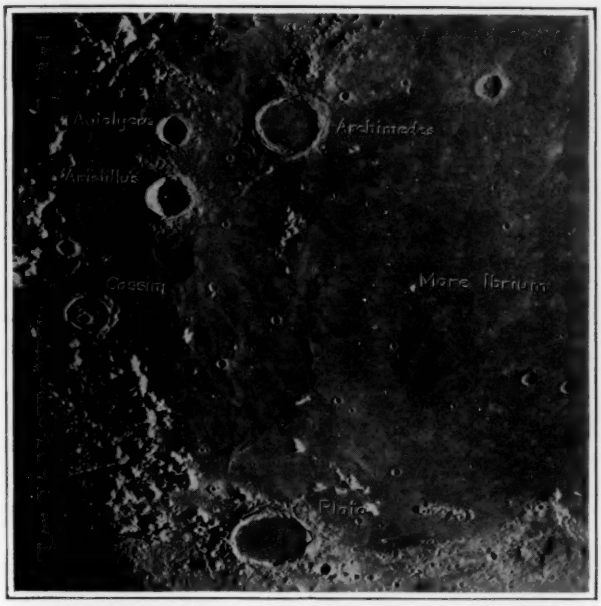
"Although the force of gravity upon the moon is capable of projecting the matter expelled to a distance six times as great as upon the earth, the theory of the production of craters by steam is practically abandoned—for it is now evident that this explanation is inadequate to explain the great difference of dimensions in craters observed."

But Pickering is mistaken. Being an astronomer he has borne in mind only the *astronomical factor, gravity*, which is in fact only one sixth as great upon the moon as upon the earth; but he has completely forgotten the *physical factor, i.e., the pressure of the atmosphere*, which is very great at the surface of the earth and nil upon the moon, since the latter has no atmosphere.

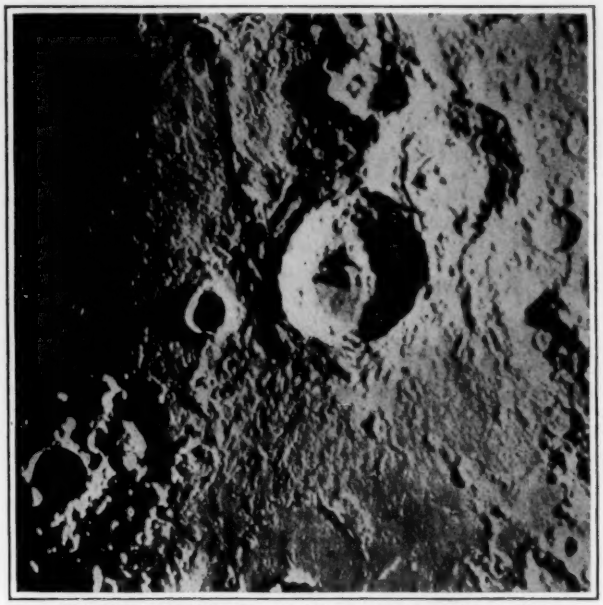
Let us try to set this difference in figures: A volcanic bomb projected upon the earth to a distance of 3 km. would attain upon the moon a distance six times as great, i.e., 18 km. because of the slight force of gravity upon the moon. Such bombs would be capable of erecting upon the moon the crest of a crater 36 km. in diameter, but not, however, a crater 100 to 150 km. in width. But upon the earth the range of a volcanic projectile is reduced to only 1/3 or 1/4 of its theoretical range in a vacuum; it is necessary, therefore, upon the moon to multiply by 3 or 4 the result given above because

*An address delivered March 30, 1919, at the Sorbonne, under the auspices of the Society of Friends of the University. Translated for the *Scientific American Monthly* from the *Revue Scientifique* (Paris).

[1]Pickering, Lunar and Hawaiian Physical Features Compared (1906).



ENORMOUS CRATERS ALONG THE LUNAR APPENINES AND ALPS



CRATER THEOPHILUS 64 MILES ACROSS AND 18,000 FEET DEEP

the lunar projectiles are launched in a vacuum. 3 x 36 = 108 km., 4 x 36 = 144 km. Thus we see that the theory is adequate to explain the matter when it is completed by the laws of physics, contrary to the opinion of Pickering.

Before we continue our examination of the volcanoes of the moon we must study an analogous problem upon the earth, namely: Is it possible for bombs shot from terrestrial volcanoes to escape into interplanetary space? The science of astronomy has demonstrated that because of the attraction of the earth, the rate of travel of these bombs ought to attain a speed of 11 km. at the extreme limit of our atmosphere, i.e., at a height of about 100 km., but the science of physics teaches us that because of the small mass and the irregular surface of those projectiles they ought to leave the surface with a speed of at least 30 km.[2] in order that the rate of speed remaining at a height of 100 km. shall be as much as 11 km. But measurements of projections occuring at Cotopaxi have given the rate as 2.5 km. per second; hence it appears to be quite certain that no terrestrial volcano has ever succeeded in projecting bombs with a velocity of 30 km.[3]

But what is quite impossible for the volcanoes upon our earth is possibly far more easy upon the moon and upon the volcanoes of satellites in general, for the reason that they have no atmosphere and that the force of gravitation upon them is very slight. And this brings us to a possible origin of meteorites and bolids; may they not be projectiles shot from the volcanoes of the moon or from all the volcanoes of all the satellites of the various stellar systems?

BOLIDS AAD METEORITES CORSIDERED AS BOMBS FROM THE VOLCANOES OF SATELLITES.

Meteories and bolids must not be confounded with the "shooting stars" of the periodoc swarms which are formed in the wake of the orbits of comets, as Schiaparelli has shown. It is the meteors exhibiting no periodicity, such as sporadic shooting stars, bolids and metorites, whose origin may be attributed to the volcanoes of satellites.

[2]The formulas employed by the naval artillery give (supposing it to be permissible to extend the extrapolation to these rates of speed) a speed which is inversely proportional (and that much nearer to 11 km.) to the diameter of the projectile. We assume here that the volcanic bombs have a maximum diameter of one meter, a maximum which is, however quite exceptional.

[3]While it is possible that the primitive volcanoes were more powerful than those of the present time, on the other hand they were surrounded by an atmosphere which was much more dense and, therefore, offered much greater resistance to their projectiles.

What then are the characteristic properties of meteorites? We know from the profound study of them made by Stanislas Meunier, that they are actual geological specimens of the earths of the Heavens and that *they have never been fused.*[4] This is one reason more for affirming the ballistic impossibility of the supposition that these stones could have come from terrestrial volcanoes. But there is still a third reason which excludes such an origin: All terrestrial rocks which like meteorites are very dense and which contain a high percentage of iron are strongly radio-active, whereas meteorites are not so at all. But all radio-active bodies have a very high atomic weight, hence it is natural to suppose that they are concentrated near the center of our system and that they are absent in the regions which are remote from the sun, in which regions furthermore those planets are found which are by far the lightest in weight. Thus the large satellites of these planets, which possess a mass and dimensions which approximate those of the moon, probably have, like the latter, volcanoes which are capable of launching projectiles into space—but which projectiles are not radio-active.

At this point we may be confronted by a serious objection, namely: How is it that the stones which occur in the Heavens can proceed from volcanoes if it be true that they have never been in a molten condition? To answer this it is necessary to extend the idea of the nature of volcanoes: Even upon the earth at the present time there exist chimneys or "necks" such as the diamond bearing chimneys of the Cape, wherein the rush of gas and vapors which escapes from them is filled with *non fused* substances. Another manifestation of what may be called merely hydrological volcanic action is found in geysers, which may be imitated furthermore in our laboratory experiments. Why then should it be considered astonishing that upon satellites where the internal heat has always been much less than upon the earth, the vapor and the gases have not been able to attain a temperature of more than 500° to 600°C., whereas the fusion of rocks requires from 1000° to 1200°C? Furthermore, upon these satellites as upon the moon, because of the low gravity which prevails the same internal pressure which operates in terrestrial volcanoes would suffice to project a column of non-fused rocks to six times as great a height—thus it is evident that the volcanoes of satellites are capable of producing the matter found in meteorites, both as to quality and as to quantity.

[4]It is only upon the surface that they are heated by the friction of our atmosphere so that they become coated with a black patina.

If it be added that the number of volcanoes upon the moon is estimated at 60,000, that each one of these has certainly undergone several eruptions, and finally, that there are a great many more satellites than there are planets, it can be readily understood why there is such an enormous number of volcanic bombs plowing their way through interplanetary space.

Let us now consider the aspect of the lunar volcanoes. These are better known to us in some respects than those of the Earth, since we possess photographs of them taken from aeroplanes (remarkable discoveries have recently been made by photographing volcanoes in Hawaii by means of kites). Upon the Moon Tycho is remarkable for its rectilinear, radial streaks, sometimes as much as 2,000 km. in length. These cannot be due to winds carrying along cinders and ashes, since there is no atmosphere; furthermore, the winds of the earth never have a rectilinear trajectory of such great length. These streaks are due, as we shall see, to direct projection of fragments of matter.

Other volcanoes, including Kepler and Copernicus also exhibit some of these streaks or trails but these are mainly quite visible streams of matter: A great many volcanoes exhibit several circular belts and central peaks from 2 to 5 km. in height, while the bottom of the craters is from 4 to 5 km. below the crest.

Let us suppose that at Paris, taken as a center, there should rise from the spot where the Eiffel tower now stands, one of the peaks of Sancy, and that a crest composed of juxtaposed Mount Blancs formed a circular belt, passing through Chartres, Vernon, Beauvais, Compiégne, Chateau-Thierry, and Fontainebleau; this would give us an idea of the formidable volcanic structures which have been erected upon the moon, because the physical forces thereon are so much superior to the forces of gravity, and it would be absolutely non-scientific to suppose that what has been proved possible upon the Moon does not occur upon the other large satellites of our system which have a similar mass or density.

THE COSMIC BALLASTICS OF VOLCANOES.

It remains to be demonstrated that the ballistics of volcanoes have been capable of projecting these missiles, not only to a distance of 2,000 km. upon the moon, as in the streaks of Tycho, but even into interplanetary and interstellar spaces. It is this which I have succeeded in doing as reported in

MAYON VOLCANO IN THE PHILIPPINE ISLANDS, 8,290 FEET HIGH

various notes to the Academy of Science[5] and to the Astronomical Society of France. I shall, therefore, merely state the results of these calculations. Upon the Moon a volcanic bomb projected with an initial speed of 500 m. per second, *i. e.*, the same as that of the shells thrown from our 75 mm. guns, in a direction forming an angle of 15 degrees with the vertical would ascend to a height of 70 km. and would fall at a distance of 75 km. Such projections would be capable, therefore, of erecting craters having a diameter of 150 km. If the initial speed is increased to 2 km., i.e., to a speed slightly less than that already observed in the projections from Mount

LOOKING DOWN INTO THE CRATER OF VESUVIUS

Cotopaxi, the range would be 1500 km.; in other words a distance equal to that from Paris to Lisbon and approximately as long as the streaks of Tycho.

Let us now consider a phenomenom of even greater grandeur whose actual occurrence the science of astronomy bears witness to, and which depends solely upon the value of the product of the radius of the moon by its density, i.e., by the weight at its surface: As soon as the rate of speed of projection of volcanic bombs attains 2250 m. these projectiles escape from the attraction of the Moon and become either satellites of the Earth or planets revolving around the Sun and in the same direction; whether the bombs become satellites or planets depends upon the direction of the trajectory with respect to the lunar orbit. These miniature planets of a new kind may even go far enough to intersect the orbit of Venus and that of Mars. Thus, the earth as well as Venus and Mars may receive in the form of bolids a rain of such bombs which escaped long, long ago from lunar volcanoes.

But it has been demonstrated by calculation that none of these bombs has either an orbit in the retrograde direction or a hyperbolic rate of speed: but investigations conducted in America by Professor H. A. Newton and in England by the Committee on Shooting Stars have established the fact that six out of every hundred meteors have a retrograde orbit, and that the rate of speed at which a shooting star strikes the earth quite frequently exceeds 72 km. per second and is sometimes even as much as 100 km. per second; in this case we are certainly concerned with the hyperbolic orbit, i.e., with a mass of matter which travelling along a curve which diverges infinitely, comes from a very great distance—or more probably even, from interstellar space into the solar system.

What is the origin then of meteors of this character? To answer this we have only to accept it as true that like the moon the great satellities of the other planets and especially of those which are very remote, also have their own volcanoes

[5] *Comptes Rendus* of the French Academy, April 25 and August 7th, 1916.

which are flooding space with their projectiles. I have made the calculation for Triton, a satellite of Neptune, and for Titania, a satellite of Uranus, and have proved that their volcanic projectiles are launched into space along orbits which may be either retrograde or hyperbolic as the case may be.

Thus we see that merely through the play of volcanic physical forces, it is possible for some of the solid matter of our system to escape from the attraction of the Sun and wander off to pay a visit to the neighboring stars. And by the same kind of mechanism the latter may also be able to send us geological messages substantially confirming what the spectroscope has already taught us, namely, the unity of the cosmic composition of the stellar universe.

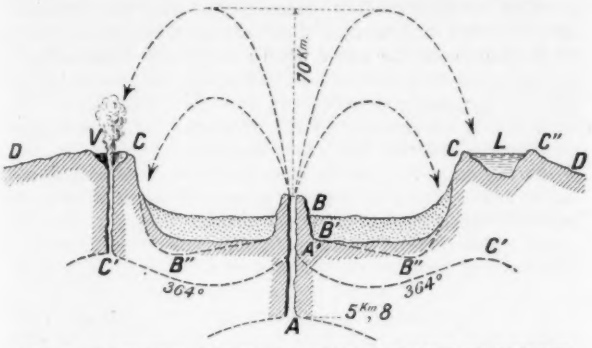


FIG. 1. MANNER IN WHICH A LUNAR CRATER IS FORMED

B, original level before eruption. Water descending into the crater erodes the entire thickness of material B B′ which the volcano hurls out building the crest C. B″ B′ B″ is the upper isothermal surface and C′ A′ C′ an isothermic surface of 364 degrees. The raising of this surface has formed small volcanoes along the edge of the crater (V, active; L, a crater lake). The hot center, 5.8 km. deep, furnishes enough pressure to hurl rocks to a height of 70 km. and over an area 150 to 200 km. in diameter.

It is clear that these researches are of the highest interest from the point of view of natural philosophy, since they result in giving us the novel ideas of an exchange of solid matter between stellar systems and of vacuous space powdered with dense volcanic dust, which may come from the very confines of the Milky Way.

But it is time to descend from these lofty heights once more to the earth—for if we now understand pretty well the external effects of volcanic action we still have to examine the nature of its internal mechanism, which is less easy to comprehend.

CHARACTERISTICS OF TERRESTRIAL VOLCANOES AND THEORIES OF VOLCANIC ACTIONS

Let us first seek to "understand the nature of volcanic action upon the Earth; a capital fact revealed by the statistics of Mercalli is of prime importance in this domain, namely, that out of 415 active or quiescent volcanoes there are 244 situated upon islands and 160 along the edges of the continent, while only 11 are found either in the center of Asia or of the Sahara desert remote from the oceans of the present time.

But in Central Asia there exist basins in the interior which do not communicate with the ocean and the Sahara has been frequently invaded by the sea. Another peculiarity which I believe I, myself, may claim to have been the first to point out is that volcanic action is strongly concentrated between the tropics, there being three volcanoes per unit of surface in the intertropical area of the earth, for one in all other regions from the poles to the tropics. This peculiarity bears a close relation to the equatorial precipitation of the last three zones of satellites of the earth, whose existence I have demonstrated, and which has given rise to the formation of chains of mountains by zones more or less close to the equator in our hemisphere. This fact must also be considered as being related to the remarkable concentration of solar spots between the latitudes + 30 degrees.

The localization of almost the entire number of volcanoes upon islands and along coasts at once suggests *the marine origin of volcanic action.* There are several theories such as those of Stanislas Meunier and of Armand Gautier which may contain a portion of the truth, but which entirely fail to explain this localization. The experiments made by Gautier are very suggestive: He has shown that granite porphyry, etc., pulverized and dried at about 100°C, liberate, when raised to a red heat, from 1 to 1.5 per cent of water vapor, together with certain gases (hydrogen, sulphuretted hydrogen, etc.), which are precisely those which issue from volcanoes. It is obvious, therefore, that it is only necessary for the internal heat of the earth to ascend into certain strata situated in the crust of the earth, in order to provoke volcanic phenomena. But how is it posible for the internal heat to approach the surface? Various objections have been proffered to the theory that the ocean is the origin of volcanic action.

Professor Brown of Geneva believes himself to have proved that volcanic action is anhydrous, but two objections have been raised against his theory: In the first place the manner in which he collected specimens of gases in active craters has been criticised, and secondly, his experiments fail to be convincing. He subjected pumice stones and clear peridots containing ferrous silicates to the action of steam at temperatures of from 750°C. to 1300°C. The ferrous silicates were altered in color to the black or red tint characteristic of ferric salts, thus indicating the oxidation of volcanic rocks under the action of water vapor at a high temperature. But it is a known fact, however, that, inversely, metallic oxides heated in a current of hydrogen may give up their oxygen and be reduced to a less highly oxidized condition. It is possible, therefore, that a current of hydrogen, mingled with the water vapor employed in Professor Brun's experiments, may have prevented by means of an inverse reaction the production of ferric oxide, and it is a well known fact that volcanoes give off hydrogen both in a free state and combined with sulphur and with carbon.

But even supposing for the sake of the argument that there were no trace of water vapor in the gases issuing from the volcanic chimney—this fact would in no way prove that water in the state of vapor is not the original motive power producing volcanic action. As a matter of fact, by virtue of the oxidation reaction established by Professor Brun, the water reduced to the state of vapor in the interior of the earth's crust might oxidize during its outward passage the basic rocks with which it came in contact, thus allowing hydrogen under pressure and at a high temperature to act upon the molten lava. Upon its issuance from the crater this hydrogen at a high temperature would combine with the oxygen of the air to produce the water vapor which is so abund-

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ONE OF THE MANY ACTIVE VOLCANOES IN JAPAN

antly found in the clouds accompanying volcanic explosions; the rocks projected outside would not have time to be appreciably oxidised during the few seconds required by their passage.

Thus chemical objections to the marine theory of volcanic action are of but little value. Let us see whether physical ob-

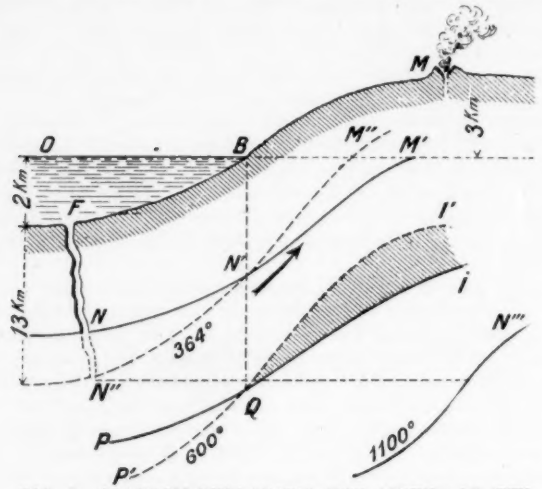


FIG. 2. DIAGRAM EXPLAINING THE ASCENT OF THE ISOTHERMAL SURFACES BENEATH THE CONTINENTS

NM′ = normal isotherm (364°C.); PI = isothermal surface in which the temperature is 600°C. The flowing of the water into the fissure FN lowers the isothermal surface (364°C.) at the point N′; the escape of the gases lifts the isothermal surface underneath the continent from M′ to M″. The other temperatures fall and rise under the same conditions. P descends to P′, I ascends to I′. The isothermal surface of 1100°C. is that of the fusion of the deep lying rocks which the water vapor issuing from the central boiler carries with it to the outside by way of the crater. OB = sea level; M = crater.

jections are worth more. It has been pointed out that numbers of volcanoes in the mountain chain of the Andes are situated at a distance of 200 km. from the sea, and that it is impossible to believe that there can be so long a subterranean inlet from the ocean. To this we may answer that the geologists are not at all afraid of assuming such a long inlet when they are trying to explain the existence of artesian wells. Thus, the artesian wells in the neighborhood of Paris are supposed to be fed by the water which filters through the green Aptien sands from the high valley of the river Aisne. Why, then, is it considered impossible that volcanic action may be produced by water from the ocean?

But, our objectors add, since the water of the ocean is of unlimited extent, if this theory be true when an eruption once began it would never stop. The geologists, who proffer this objection, simply forget that water in a state of vapor at a high temperature is a very energetic chemical agent, oxidising the rocks it comes in contact with, and that, moreover, ocean water contains 3.65 per cent of various haloid salts. The oxides formed and the salts remaining after the evaporation or decomposition of the water would be deposited in the subterranean aqueducts and would finally choke the mouths of these so that the volcanic action would be arrested, at least for a time.

But it may be asked how volcanic action, which has been progressively arrested after a convulsion, can be made to start up again? This is simply because the subterranean channels into which the salts were deposited at temperatures below 500°C. being no longer cooled by the deposit of the sea water would again rise in temperature up to 700 or 800°C., the temperature at which the mineral salts found in the sea are fused and volatilized. A fact which proves that things happen like this is that an eruption generally begins with dry fumeroles at a high temperature which contain chlorides chiefly.

Lastly, a final objection very widely found in books upon geology is to the following effect: If the water from the bottom of the ocean descends into the crust of the earth through fractures in the latter and is there reduced to steam, then the pressure of the latter ought to drive back the water through the passages whence it came. This objection proves that one may be a very good geologist and yet be ignorant of the physical laws governing water and boilers—here we have an example of the danger resulting from too narrowly dividing the sciences into separate compartments. But every engineer well understands that in any industrial boiler the path followed by the water when going to be vaporized is not the same as that followed by the steam when the latter is leaving the surfaces where it has been vaporized. Why then should water vapor in the terrestrial boiler be expected to follow a different law from that which controls it in the industrial boiler? And the said law is very simple, namely: *water follows the path imposed upon it by the laws of gravity whereas vapor follows the isothermal surfaces*, i.e., those surfaces where the temperature is sufficient to maintain it in the state of vapor.

NEW MARINE THEORY OF VOLCANIC ACTION.

The law stated above leads us directly to a very simple explanation of volcanic action and to the experiments which have enabled us to produce such action experimentally.

Let us first try to find out, therefore, what becomes of the ocean water which penetrates the crust of the earth through a fracture in the latter in the neighborhood of a steep coast line. At the bottom of the sea, which is at least 2,000 m. deep and which communicates freely with the polar region, the temperature is very close to zero (Centigrade). The same thing is true at the top of a mountain near the coast which rises to a height of 3,000 m. To find within the ground a temperature of 100°C. we must descend 3,000 m. inside the mountain as well as underneath the bottom of the ocean; in a word the lines or surfaces of equal temperature, *i. e.*, the isothermal lines or surfaces, will be very much inclined to-

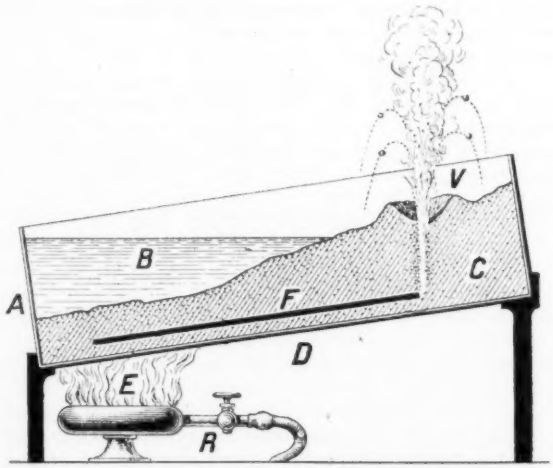


FIG. 3. THE EXPERIMENTAL BASIN DEVISED BY M. BELOT: SECTIONAL DIAGRAM

AD, tank of sheet metal; B, water; C, sand; F, slate; V, volcano; E, gas flame regulated by the stop-cock R. The heat of the flame E causes the water contained within the sand to come to the boiling point only where it is in contact with the bottom D. The steam escapes underneath the miniature continent forming a crater, while the water B remains cold.

wards the sea and the steeper the coast the greater the degree of this inclination. But because of the enormous pressure (200 atmospheres) which prevails at the bottom of the sea, the water which penetrates the fracture (Fig. 2) will not be turned into vapor at 100°C. and does not arrive at

this state until it reaches the isotherm of 365°C. at about 13 km. below the bottom of the ocean; in other words 365°C. is, as a matter of fact, the *critical temperature of the water*, so called *because of the fact that at that point water exists in the state of vapor no matter what the pressure may be.* The isothermal surface of 365°C. will be like all the others practically parallel to the external solid surface, *i. e.*, it will ascend towards the continent. Since the vapor is obliged to follow the isothermal surface it will, therefore, ascend along this surface towards the continent in place of trying to drive back the water in the fissure. The strata of the earth being cooled by the passage of the sea water, the isothermal surface will run downwards from N′ towards N″ beneath the ocean and through the calorific action of the vapors will ascend within the continent to M″ which will increase still more the slope of the isotherms. All of the isothermal surfaces already inclined will follow this see-saw motion which is favorable to the exit of gases and vapors from the continental surfaces. Thus we see that *volcanic action will begin by an eruption of gases and vapors*, contrary to the views of T. See and of Contejean, who are of the opinion that the marine theory indicates the immediate issuance of lavas under the supposition that the latter must be under pressure beneath the continent through the vapors produced in the bottom of the seas.

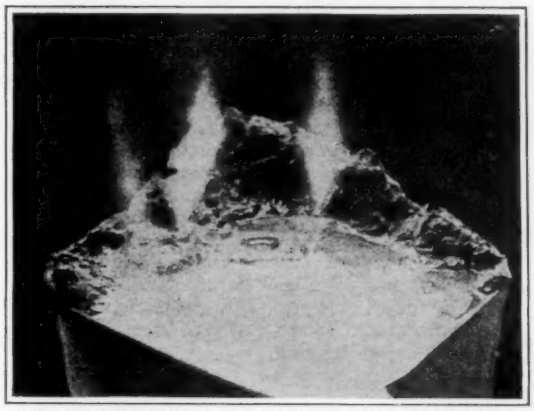
But it may be asked how the marine theory can explain the arrival of lavas at the surface when the temperature of fusion of rocks (cc. 1,000°C.) is in general not attained except at a depth of about 30 km. and when at the level N″ the weight of the salt water in the ocean and in the fissures is certainly not more than one-third as great as a column of lava of the same height and especially since such a column of lava sometimes rises as much as 3 km. above the level of the sea. We answer that this occurs through the same paradoxical process which, in industry, causes a column of hot water to rise to a height of 10 m. when subjected to a pressure of 1 m. of water only, or of 0.1 atmosphere; in the same way we have in the ascending column *an emulsion composed of vapor and hot water*, whose average density is much less than that of the water. If we assume that in its subterranean trajectory the vapor finds molten lava at the point N″ and a passage of exit in the vicinity of the apex of the continent M, then the two fluids, the vapor and the lava, will mingle at this point, the vapor having, because of the enormous pressure, a density close to the critical density 0.33, and the lava having a density of 2.7.

If the emulsion formed contains a volume of vapor four times as great as that of the lava, this is all that is necessary to cause the latter to make its appearance under a strong pressure at the point M, having ascended 3 km. above the sea level. This novel marine theory can be verified by experiment, at any rate within certain limits, in a laboratory. I have succeeded in reproducing all phenomena of volcanic action by endeavoring to produce in a shallow basin L. 60 m. by 0.60 m. an inclined isothermal surface D, heated beneath by a heater E (Fig. 2). For this purpose the basin A is filled with a argilaceous sand C representing a continent near the coast where the bottom is elevated, while the water B represents the sea. The sand is entirely permeable by the water, and if the theory accepted by so many geologists were true, we should expect to see the sand lifted by the vapor above the heater E—but this does not occur. The vapor follows the sloping ascent D and does not escape until it reaches the top of the slope, first forming fumeroles and causing at V projections of solid matter which forms a crater. If we interpose in the midst of the sand a horizontal stratum of red iron oxide, the latter in spite of its density will ascend within the volcanic chimney and be projected upon the miniature continent in the form of red volcanic bombs.

By these experiments we have produced the paradoxical phenomenon of a "volcanic V" at 100°C., while the "sea" above the heater is entirely cold. In order to reproduce the case which so frequently occurs in nature of impermeable strata, alternating with permeable strata we may place a slab of slate F a little above the bottom. In this manner we were able to obtain new effects, namely, multiple volcanoes, operating simultaneously and a race or bore. When the piece of slate touches the bottom D of the coast of the continent, we can also produce submarine volcanoes whose crest will gradually rise in a circular form above the level of the miniature sea.

A general view of the miniature basin which I have made use of to represent experimental volcanic action, shows in the center a crater-lake produced by the preceeding experiments, an eruption just beginning (at the right), and an ruption which is beginning to form its crater and is heaping up upon its external slopes a concretion of ejected matter (to the left); finally in front of the latter crater there is an extinct crater showing the orifice of its volcanic chimney.

The experiments described and the theory which suggested them lead us to the general conclusion that there is a subterranean connection between the volcanoes and the ocean, and that the vapors of the waters are directed towards the substructure of the continents by the inclination of the isothermal surfaces.



THE EXPERIMENTAL VOLCANO IN FULL OPERATION

In the center toward the front appears the crater-lake formed by a preceding experiment; to the right is shown a volcano in which the eruption is beginning; to the left at the rear is shown a volcano which has already formed its crater and covered its slopes with bombs; to the left in front is shown an eruption which is almost finished, the crater and the orifice of the volcanic chimney being visible.

The general law governing volcanic action may, therefore, be formulated as follows: *Volcanic action in relation to the water of the ocean is proportional to the steepness of the continental slopes and to their degree of convexity with respect to the ocean.* This law can at once be verified by the islands in the open seas, since these are nearly always volcanic in character because of the fact that the isothermal surfaces here form a cone which concentrates the vapors at its apex.

INTERNAL FRICTION IN THE ATMOSPHERE.

A RECENT German journal (Th. Hesselberg, *Annales der Hydrographic und Maritimen Meteorologie*, Part V.-VI., 1919), contains a discussion of the influence of internal friction on the relation of the surface wind to the pressure gradient. Much of the paper follows the lines of G. I. Taylor's paper of 1915. It is shown that certain pilot-balloon observations at Lindenberg agree with the theory that turbulence is independent of the height. The results make the eddy viscosity 4.2 x 10^4 cm^2/sec. Attempts are made to deal with pressure gradients and eddy viscosities varying with the height; but these are vitiated, the first by an incorrect integration of the equations of motion, and the second by the use of a wrong form of these equations themselves.

Charting the Mind

Modern Apparatus Employed in Psycho-Physics

By T. A. Marchmay

AN entertaining story is told of a small girl who, after being sunk in a brown study for several minutes, suddenly exclaimed, "Why nobody knows what's inside of me, except what I tell them myself!" The anecdote is not only illustrative of the dawn of self-consciousness of the individual mind, but suggests likewise the dawn of self-consciousness in the race. At some point in man's upward progress he became conscious at once of his indwelling spirit and of the isolation of that spirit.

More and more through the long ascent of centuries man has been occupied with the problems of the nature and origin of his own spirit and with its relationship, not only to the body that houses it but to the spirits of other men, whether dead or living. But whether among savages, among the schoolmen of the middle ages, or among the metaphysicians of the 17th, 18th, and even the early 19th centuries, the spirit has always been considered as something esoteric, a thing fettered by the body and subject to temptation from the latter and yet something intrinsically apart.

It is not our intention here to enter upon any debate as to the true nature of the spirit of man. Whatever its nature, whatever its origin, whatever its destiny, it is, while an occupant of its earthly tabernacle, subject to approach only through the gateways of the senses. It is the comprehension of this fact which has fundamentally altered the methods employed in psychological study of recent years. In short, psychology has at last taken its rightful place among its sister sciences —those sciences whose insignia are the balance and the measuring rod. In the words of an eminent modern psychologist, Dr. John B. Watson, of Johns Hopkins University: "The key which will unlock the door of any other scientific structure will unlock the door of psychology. The differences among the various sciences now are only those necessitated by the division of labor. Until psychology recognizes this and discards everything which cannot be stated in the universal terms of science, she does not deserve her place in the sun."

It is the purpose of those pages to give some brief account of the modern apparatus by means of which psychology has been enabled to assume more and more the character of an exact science, with definite and immutable laws governing individuals and groups, thus breaking down those barriers of isolation between mind and mind which language has but imperfectly bridged.

In his study of a given individual the psychologist applies certain tests whose results give him a very definite notion of the capacity of the individual before him, and of the class or group to which the individual belongs, when the said results are properly correlated in large numbers of instances. To begin with, what are known as anthropometric tests are applied. These include the diameter and girth of the skull, the weight, and the height, both standing and sitting. Secondly, come tests of physical and motor capacity, among which are the strength and endurance of grip, the strength of the back and legs, the speed of movement as shown by the act of tapping, the accuracy of movement as shown in taking aim and the steadiness of movement as shown in the act of tracing; this group also includes tests of the steadiness of motor control as shown by involuntary movements, and finally, what is known as vital capacity.

Of prime importance, of course, are the tests of sensory capacity, which include not only a delicate discrimination as to the sensitiveness and accuracy of the eye, the ear, the nose, the taste, and the touch, but also the sensitiveness with respect to pain and to pressure as well as a discrimination between dual impressions upon the skin. Lastly, there are various tests with respect to attention and perception, memory and other faculties of the intellect.

The fundamental principle underlying the conduct of all these tests is the same as in other sciences, namely, the *standardization of conditions.* If the conditions are varied they must be varied intentionally and for a definite purpose. Furthermore, no detail in the conditions governing the tests is trivial enough to be neglected.

First of all the laboratory itself must be carefully arranged according to certain specifications. It must include both dark rooms and rooms which are sound proof. It must be provided with electric power and it must be free from objects extraneous to the test in hand which might serve to distract the attention of the subject. The laboratory of psychology at Harvard, for example, comprises more than 20 separate apartments including five dark rooms, a sound-proof room, several rooms devoted to animal psychology together with the necessary vivarium, a library, a museum of apparatus, etc.

Since optical and auditory researches involve a knowledge of the laws of physics, there must be a physical laboratory forming a part of the installation. There must likewise be a chemical laboratory, since measurement of taste, odor, and chromatic sensations are made by means of certain chemical reagents. Among the general apparatus required are high power microscopes, delicate balances, thermometers, barometers, hygrometers, hydrometers, and various measures of length, surface and capacity. Other general apparatus are chromoscopes, cylinders, electric signals, devices for causing disks to revolve at various speeds, etc.

These instruments, all of which must be as perfect as possible, especially with respect to precision, have been combined in one way or another to form an enormous number of ingenius devices. These are so multifarious that they defy description in a single article. However, it is possible to describe certain types of the most important apparatus now in use in the laboratories of America, France, England and Germany.

These descriptions, with the accompanying illustrations, will it is hoped, give the reader some understanding of the value of modern psychological methods, and enable him to see why it is that the psychologist is increasingly called upon to lend his aid to the physiologist, the physician, the teacher, the jurist, and the industrial employer in every line of human endeavor.

Fig. 1. represents the olfactometer. Here the subject is holding a vial containing an odoriferous substance to one nostril, while the other is stopped with cotton. The vial contains a few drops of a fragrant essence or solution and the odor is received through a glass tube sliding inside a paper tube, closed with a stopper at its lower end and immersed in the receptacle; the test is made by seeing how far it is necessary to lift the glass tube, thus uncovering the paper tube through which the odor is diffused before passing into the glass tube in order to produce a sensation. By knowing the time required to lift the glass tube, the surface of paper uncovered (but with the disadvantage that the paper is not a definite body), and the co-efficient of the evaporation of the fragrant body in a single unit of time determined by the vapor balance it is possible to calculate the weight of the amount of evaporated substance which has passed into the apparatus and been received within the nostril. However, the vapor balance requires such delicate manipulation that some authorities criticise this method because of the difficulty of obtaining sufficient precision from the data furnished by the said balance.

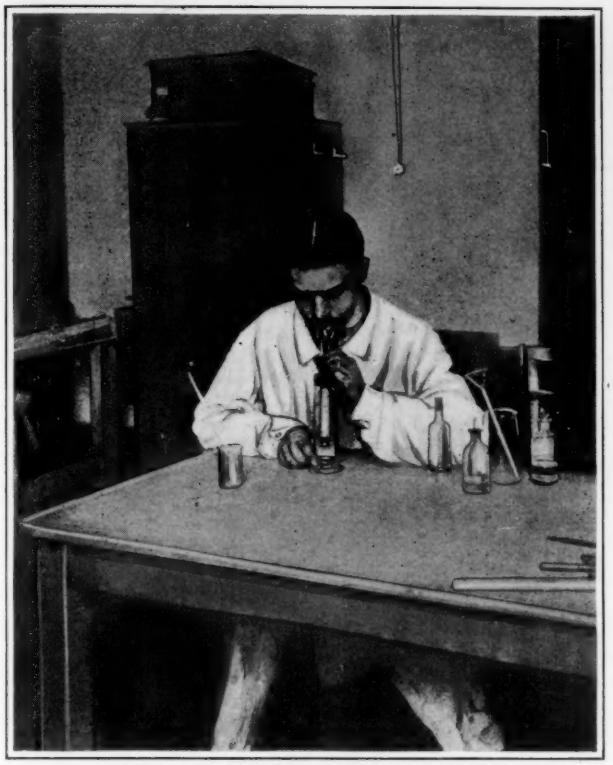


FIG. 1. TESTING THE SENSE OF SMELL

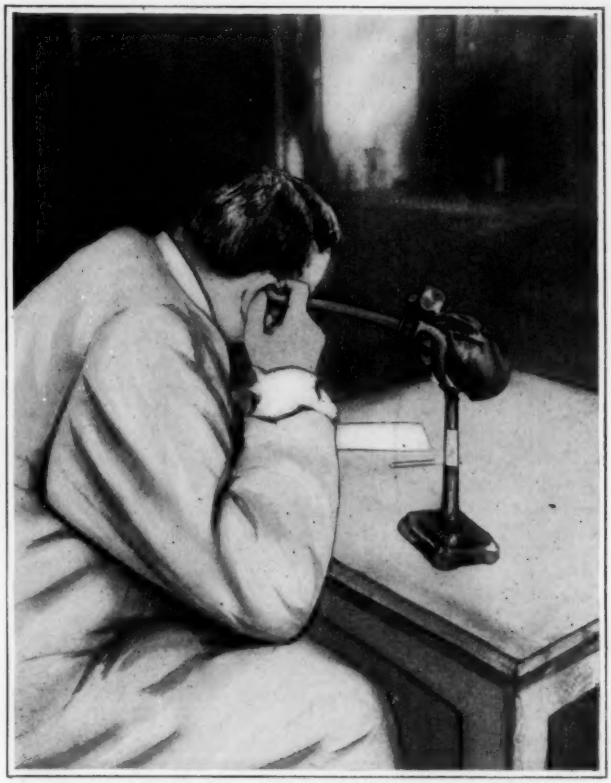


FIG. 2. MEASURING THE SENSATION OF HEARING

In the method employed by Dr. Toulouse the keenness of the olfactory sensibility is measured in a perfectly calm and non-odorous atmosphere, at a temperature of 15°C. by means of 15 ccm. of an extremely weak solution of camphorated water contained in a glass tube having an internal diameter of 0.02 m. and an internal height of 0.06 m. with an emery stopper having an internal length of 0.01 m.; this tube is presented to the nostrils of the subject (the latter not being allowed to see it) for the space of three seconds and during an aspiration of average amplitude, in such a manner that the opening of the tube touches the nostrils and gives a *sensation* (i.e., an indefinite olfactory impression) or a *perception* (i.e., a recognition of the camphor). A control experiment is provided by presenting to the nostril of the subject a tube filled with distilled water.

A further step is the testing of the subject's capacity for perceiving and recognizing odors, by presenting to his nostril various solutions containing definite percentages of familiar fragrant substances, such as olive oil, orange flower water, violet water, rose water, garlic water, camphor, vinegar, etc. Aqueous mixtures are used instead of alcoholic solutions to avoid interference by the odor of the alcohol; in these cases the water acts mechanically by dividing the particles of the essences which would furnish too intense a stimulus in their pure state.

Finally, the non-olfactory sensibility of the pituitary mucous membrane can be measured by determining the weakest possible solution of ammonia at 27° C., or of ether, capable of occasioning a sensation or a perception.

The apparatus constructed by Toulouse and Vaschide to carry out these various tests is known as the osmi-esthesiometer and comprises a series of 54 vials of cylindrical form each having an internal height of 6 cm. and an internal diameter of 2 cm. and each having an emery stopper penetrating the vial for a distance of 1 cm. These vials are contained in two copper supports, placed in a wooden frame. One of these supports contains ten vials holding various odoriferous substances, while the other contains the series of vials holding solutions of camphor, of etherized water, and of ammoniacal water.

In Fig. 2 the audiometer of Professor Charles Henry is shown. This, as its name implies measures the delicacy and accuracy of the sense of hearing.

The auditory sense is tested for the impressions received with respect to the intensity of musical sounds or of noises, to the height of the note and to the timbre. The latter quality, however, results from a simultaneous complex of a great number of sounds of different heights; hence, its objective analysis is too difficult to permit the determination of exact measurement. Therefore the intensity and the height of the sound and its persistence are the characteristics chiefly studied.

A great variety of methods have been employed to determine the minimum sound perceptible. One method commonly utilized consists in a progressive increase of the distance between the subject and the source of sound, the latter having a definite degree of intensity taken as a constant. The source of sound may be a watch or clock, an electrically vibrated tuning fork, etc. The change of distance is made by a change of place, either on the part of the subject or on the part of the sonorous object; in this way the comparative distances at which different individuals cease to detect the sound can be determined. This change of place, however, is somewhat clumsy and tedious, and therefore, to avoid the necessity of it Professor Charles Henry has invented his audiometer in which there is interposed between the source of the sound and the ear of the subject an ebonite disk pierced with an orifice of known dimensions having a diaphragm of variable aperture; this instrument enables the investigator to compare the aperture and likewise the objective degrees of intensity upon the assumption that in each case the degree of intensity is proportional to the squares of the apertures of the disk and of the diaphragm.

A number of acoumeters have been constructed upon the principle of the telephone. In these the source of sound is a vibrating diaphragm and there is a rheostat which permits

the operator, by increasing the resistance of the circuit to diminish the degree of intensity transmitted to the receiver, which is held to the ear of the subject.

Another series of apparatus is based upon the principle of a variation in the intensity of the sound *produced* instead of upon a variation in the intensity *transmitted*. This is accomplished by allowing various bodies, such as hammers, metal spheres, cork balls, etc., to fall upon a constant metal surface, from varying heights.

This latter class includes the acousi-esthesiometer of Toulouse and Vaschide. In this apparatus the falling bodies consist of drops of distilled water, of a constant weight falling from a gradually increasing height upon a definite metallic object (an aluminum plate). Aluminum is chosen because it does not become oxidized, and the plate is inclined at an angle of 30 degrees to prevent the drops of water from accumulating and diminishing the sound of the vibration. A flask containing distilled water is attached so as to slide up and down to a standard, and the drops are allowed to fall with more or less rapidity by means of a stop-cock controling an orifice of variable size. All these apparatus, of course, must to be operated in an absolutely sound-proof room.

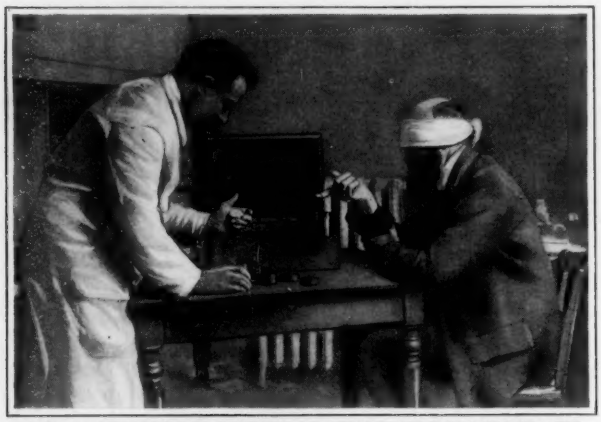


FIG. 3. MEASURING MUSCULAR SENSITIVENESS WITH THE MYO-ESTHESIOMETER

It is obvious that the precision obtainable by this instrument in denoting the degree of acuteness possessed by the ear would make it valuable in examining applicants for telephone operators as to their fitness for the post—a fitness at present only too often lacking.

In Fig. 3 there is shown the myo-esthesiometer devised by the well-known psychologists, Dr. Toulouse, Director of Experimental Psychology at the *Ecole des Hautes Etudes* of Paris and his late collaborator, Dr. N. Vaschide, for the purpose of measuring muscular sensitiveness. Here, the subject is blindfolded and is guessing weights by means of his muscular reaction.

The subject of muscular sensitiveness comes under the general head of the measurement of subcutaneous sensations. Not all of the networks of nerves possessing general sensibility are found near the surface of the skin; a large number of them start in the muscles, the tendons, the joints, the bones, and other parts of the organism capable of being the seat of sensation. The principle ones of these sensations having their origin in the deeper portions of the body include the vibratory sense, which is located chiefly in the bones, and the kinesic or kinesthetic sense, which is often called the muscular sense, and which is located mainly in the muscles, but also in the joints and even in the tendons.

To determine the absolute limit of sensibility to vibratory intensity, the instrument commonly employed is a sort of tuning fork, the one generally adopted being the acoumetric tuning fork of Pierre Bonnier. This tuning fork is set in vibration by suitable means and the rate of vibration is measured by a chronograph, or better still by photography. The forearm of the subject is extended with the closed fist resting upon its anterior surface upon a cushion. The experimenter sets the tuning fork in vibration, and at the same moment starts the hand of a pocket chronograph. He then places the tuning fork vertically by its handle in a state of equilibrium upon the top of the second knuckle and asks the subject to advise him of the instant when he ceases to perceive the vibration; at this instant he immediately moves the tuning fork into the same position upon the top of the third knuckle; the subject will again begin to perceive the vibrations and will again tell the experimenter when he ceases to perceive them. At this exact moment the experimenter will press the button of his stop watch and note the time elapsed. The necessity of changing the bone examined is due to the rapid fatigue to which vibratory sensibility is subject.

Kinesic Sensations.—The principal kinesic sensations to be studied consist of muscular effort exerted against a resistance as in the lifting of a weight; of static contraction, immobilizing a limb or any part of the body in a certain position, and dynamic contraction, *i. e.* a movement displacing a limb or any segment whatever of the body within certain definite limits.

Sensations of Muscular Effort.—The acuity of muscular sensibility can be measured by the smallest possible ratio between two copper buckets of similar volume and form, one of which employed as a standard maintains a constant weight, while the other has its weight progressively augmented by the addition of flat weights; these buckets after having been alternately suspended without any perceptible shock to a segment of the limb are differentiated. The myo-esthesiometer of Toulouse and Vaschide consists of a series of such buckets having the following weights:

First series	1 gr.
Second series	10 gr.
Third series	100 gr.
Fourth series	1000 gr.

The 1 gr. buckets are made of aluminum and the others of copper. Within the bucket of variable weight in each series there are placed flat weights of known weight permitting the value of the bucket with respect to the constant standard to be increased in the ratio of 1/1000, 1/100 and 1/10. In each series these flat weights are ten in number of a value ranging from one unit to ten units. In the first series the weight of the unit is 1 milligram, in the second series 1 centigram, in the third series 1 decigram, in the fourth series 1 gram, in the fifth series 1 decagram, in the sixth series 1 hectogram. In the first, second and third series the weights are made of aluminum, while in the fourth and fifth series they are made of copper. They are cylindrical in form and are surmounted by a hook.

The subject is seated in a comfortable and definite position by the side of a table in such a manner that his elbow alone is able to rest upon one edge of the table, while his arms are held in a horizontal position away from the table. The subject is blindfolded and told that he is desired to judge the weight of the little buckets by holding them in his hand and to tell the experimenter which seems to him the heaviest; in case he fails to receive a precise impression he is requested to say "I do not know."

The buckets are placed upon the joint of the index finger which is almost fully extended and the subject is then asked to judge the weight of the bucket by a movement of the forearm which is lifted from the elbow (the latter being supported as stated above) while the fist remains immobile and all the fingers of the hand except the index finger remain closed. Thus the muscular sensibility appertains almost solely to the biceps and to the anterior brachial muscle, on the one hand, and to the opposing triceps on the other hand. Triple presentations are made: the standard of a series is first presented, then another weight, and then the standard

again proceeding progressively from the weight which differs least from the standard, to the one which differs most. Between any two triple presentations there must be an interval of one minute in order to avoid fatigue, and after three or four triple presentations the subject must rest for several minutes, especially if the weights are heavy.

When the responses of the subject are found to be constantly exact, one obtains the value of a differential limit or "threshold" measured by a fraction, whose numerator consists of the weight in grams of the excess load added to the bucket having an adjustable weight, and whose denominator consists of the weight in grams of the bucket used as a standard.

In order to determine the absolute threshold of sensation one must produce anesthesia of the surface of the skin since otherwise the sensations of pressure, which precede the muscular sensations would render exact measurements impossible; this is accomplished by placing ethyl-chloride upon the index finger.

But it is possible to measure not only sensory sensibility and energy, but purely intellectual phenomena, such as memory, imagination, logic, the power of association and of abstraction, the capacity for discovery, etc.

Memory, of course, exists in animals, in a more or less rudimentary form and interesting comparisons can be made between this power as shown in animals and as exhibited in children and adults. All of the sensory perceptions can be remembered, and such memories may be very complex, particularly in the case of the five senses. Thus in auditory memory alone the mind can retain the impression not only of simple notes, but of chords, arpeggios, and tunes.

Visual memories have been classified under the heads of 1: Tables of complex, straight and curved lines; 2. Concrete objects; 3. Attitudes and expressions; 4. Complex scenes and physiognomies.

Finally, there are memories of words, phrases, and intellectual concepts.

Many tests of memory can be made of course, either with no apparatus or with nothing more elaborate than a piece of paper and a pencil, or a blackboard over which a shutter can be swiftly drawn.

Fig. 4 shows Lahy's electro-magnetic apparatus for this purpose.

Sensations of heat and cold can be measured in various manners. A clever device for this purpose is the thermoesthesiometer of Toulouse and Piéron. This consists of a double metal funnel having an electric resistance between its two walls. The end of the funnel is provided with a stopcock regulating the flow of drops of distilled water through a calibrated orifice. A thermometer is immersed in the funnel, the end of the reservoir being above the level of the orifice; a spiral agitator surrounding the thermometer maintains a homogeneous temperature of the mass of water. A cardboard screen is placed at the base of the funnel with an orifice for the passage of the drops. An important feature in the use of this device is to allow the drop of water to remain on the skin very briefly, since evaporation at once produces a cooling sensation.

SENSATIONS OF PAIN.

Cutaneous sensations of pain have the peculiarity of being excited by a wide range of stimuli including pressure, pinching, piercing, heat and cold, and electric discharges. This is why pain was long held to be a concomitant of any violent exertation, instead of a definite sensation, as it has now been demonstrated to be. It is measured by various instruments, one of which is the algoesthesiometer of Toulouse and Piéron.

Fig. 5 shows the method of testing susceptibility to heat and cold. Here the subject is measuring calorific sensations with his hands crossed.

STATIC SENSATIONS.

There are certain sensations which enable us under normal conditions to recognize the position of the limbs and of various segments of the body with respect to each other, even when we have forgotten the movements to which these attitudes are due. Thus when we first wake in the morning we know whether we are lying on the back or on one side and whether the limbs are drawn up or extended.

An instrument designed to permit the study of static sensation in the arm is the schesi-esthesiometer of Toulouse and Piéron. This consists of a grooved standard and a circular support which can be inclined so as to swing backward and forward. The surface of the support can be placed by means of the grooves at any distance above the ground from 0.90 m. to 1.90 m. The foot of the standard can be moved upon the surface of a circular piece of linoleum upon which there is drawn a central circle and a series of radii separated by distances of 10 degrees.

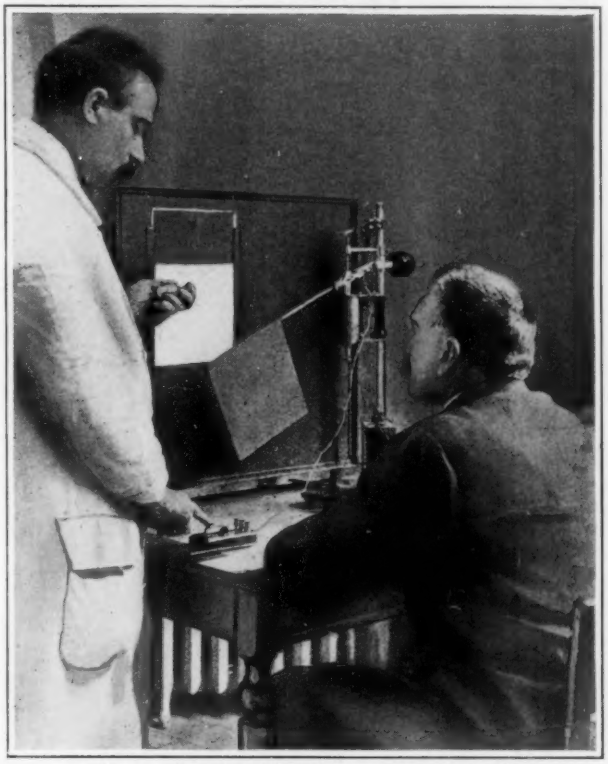


FIG. 4. ELECTRO-MAGNETIC APPARATUS FOR TESTING MEMORY

The arm is placed in a given position with the hand resting upon the support which is so inclined as to be in a straight line with the axis of the extended arm; this position can then be defined as regards its height and its angular distance with respect to a plane which is perpendicular to the interocular line. The subject is required to compare this position with other positions.

DYNAMIC SENSATIONS.

Dynamic sensations are those which give us information as to the extent of movements of the limbs or of segments of the body. The instrument described above can be employed to study the differential sensibility of passive movements of the wrist joint. The hand being placed in the usual position upon the support and brought to the height of the horizontal plane of the extended arm; the support is then inclined at a constant rate of speed and at a definite angle, *e. g.* at an angle of 30 degrees per five seconds; then after having again placed the hand in the horizontal position, the movement is recommenced at the end of five seconds with the same rate of speed and a displacement of somewhat greater or somewhat less extent is made. The subject is required to inform the experi-

menter as soon as he can perceive a difference in the extent of the displacements, and which appears to him to be the greater. The difference between the two displacements is gradually increased until exact responses are obtained determining the threshold of sensation (*i. e.* a detected difference) and the threshold of perception (*i. e.* the determination of the extent of the difference). The habitual test consists in effecting the same displacement twice in succession.

Active Movements.—Active movements are studied by causing the subject of experiment to displace a movable body along a definite distance. There are various apparatus employed for this purpose; sometimes grooved boards are used, a pencil

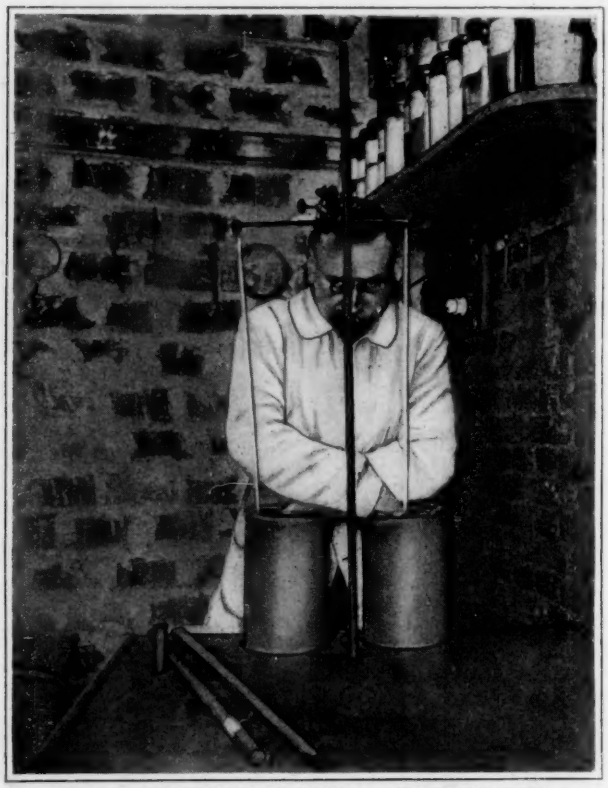


FIG. 5. MEASURING CALORIFIC SENSATIONS WITH CROSSED HANDS

being employed to follow the contour of the groove. This method enables the experimenter to determine the threshold of differentiation of forms—for example, by causing the subject to follow the contour of circles which have been more or less flattened so as to assume an elliptical form it can be determined what is the slightest degree of flattening capable of being perceived.

Various other apparatus have been devised to measure the extent and precision of various dynamic motions.

MEASURING THE SENSE OF TASTE.

The sense of taste is so closely connected with that of smell that it is often difficult to differentiate the two, and there are in fact a large number of pseudo tastes or savors which result from the collaboration of these two senses. Fortunately, however, certain stimuli exist which have a distinctive effect upon these organs, thus enabling them to be isolated for the purpose of study.

Some experimenters make use of powders to stimulate the sense of taste while others employ solutions, which are placed upon the tongue by means of the finger, a brush, a sponge, or a tube; others still make use of electric currents.

Certain definite methods have been formulated by Dr. Toulouse for the study of taste. He makes use of salt, for salty savors, of saccharose to produce sweet savors, and of quinine for bitter flavors and of citric acid for acid flavors. These substances are not only well defined and familiar to all normal subjects but are readily soluble in distilled water.

These solutions are prepared in decimal series. Each is placed in a flask through whose rubber stopper a dropper is inserted. The dropper is carefully made so as to produce standardized drops having a constant volume of one-fiftieth of a cubic centimeter whatever the concentration and having approximately the same weight. Sixty of these flasks are placed in a frame made of copper which can be placed in a water bath so as to maintain a constant temperature of 38 degrees centigrade. This apparatus is called a gueusi-esthesiometer. The flasks must be protected from evaporation since this will alter the degree of concentration. Furthermore, they should frequently be refilled. The drops are allowed to fall upon the tongue from a height of one centimeter. At this distance there is practically no sensation produced by contact—thus the only sensation experienced is that of taste. The subject of the experiment is seated comfortably with his head held by a support and is then told to extend his tongue as far as possible. The surface of the tongue must be perfectly dry before the application of each drop so as to prevent diffusion, which would interfere with the accuracy of the experiment, especially in cases where certain definite areas of the tongue are being tested with regard to specific sensibility. The tongue must be held perfectly steady, if necessary by holding it in the hand, the latter being covered with a handkerchief. The subject must obey the orders of the experimenter promptly, either holding the tongue extended or withdrawing it and pressing it against the palate in the endeavor to bring out the taste of the applied drop. There is an interval of one minute before the fresh drop is applied. In the case of bitter substances this interval is necessarily much longer, extending even to five minutes, since bitter tastes have a tendency to persist. After each application the mouth must be rinsed with 5 ccm. of distilled water having a temperature of 38° C.

THE MEASUREMENT OF VISUAL SENSATIONS.

The sensations derived from the eye are extremely complex and their investigation is, therefore, a matter of much delicacy. The eye is measured first with reference to its capacity for luminous sensation, tests being made for the perceptible minimum of sensation and for the differential minimum. Secondly, it is measured with respect to its capacity for chromatic sensation, *i. e.*, its sensitiveness to color. The first tests have reference to sensibility as a whole to chromatic intensity. Next the extreme limits of chromatic sensibility are determined. Thirdly, the power of differentiation between chromatic tones is made, and lastly, the sensibility to shades and to chromatic saturations is determined.

Other tests include those for keenness of vision, for the extent of the visual field, and for the persistence of luminous impressions. In these various branches of visual measurement a large variety of apparatus is used for which the best optical glass, including lenses, prisms, ground glass plates, etc., must be employed. Furthermore, there must be all sorts of spectacles to correct abnormal vision. The importance of this will be recognized when it is remembered that a large percentage of individuals have eyes which are unlike each other, in one respect or another, besides the difference between individuals. Furthermore, even in a perfectly normal eye the focusing power gradually and continually changes with increasing age. One of the commonest instruments used to determine luminous sensibility, is the photoptometer of Charpentier, an arrangement of two plano-convex lenses in a tube having between them a diaphragm provided with a device sometimes known as a "cat's eye," *i. e.*, an aperture which can be made wide or narrow at will by means of an adjustable shutter. A ground glass plate covers the end of the tube.

The subject of experiment must remain for a quarter of an hour beforehand in a dark room, so that his eye is adjusted to entire obscurity. The photoptometer is placed upon

a table and the electric bulb forming the source of light is placed in a dark box connected with the tube of the apparatus, in such a manner that not a single luminous ray, except those which enter the tube can pass into the room. The subject has the eye piece to which he must apply his eye indicated to him by the sense of touch. When he first applies his eye the

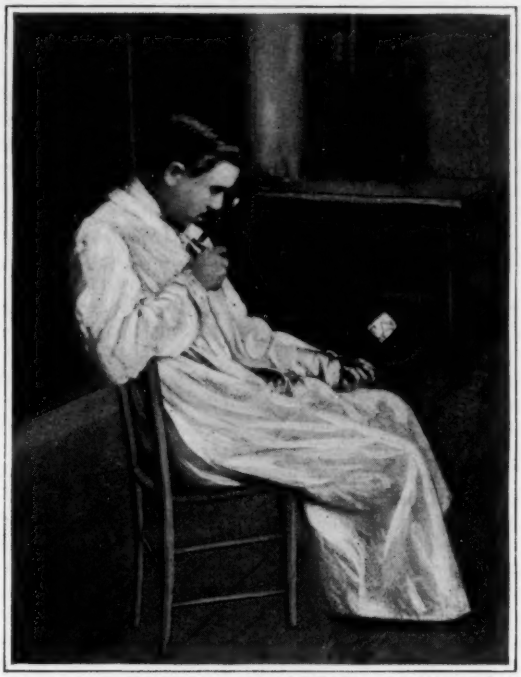


FIG. 6. DETERMINING THE DEGREE OF DILATATION OF THE EYE

adjustable aperture is completely closed; he then removes his eye and the aperture in the diaphragm is gradually opened, the subject applying his eye every twenty seconds, for a period of two seconds each time. He is required to announce the exact instant when he believes himself able to observe even the faintest degree of luminosity upon the screen.

The differential minimum is obtained by the differential photoptometer. This is made by adding to the tube of the simple photoptometer a rectangular box, upon which is mounted at a right angle a tube identical with the first. Two luminous sources of equal intensity are placed opposite each tube at the convergent focus of the lenses opposite the plate of ground glass; the adjustable apertures are open to the same extent. But the light which comes from the second tube encounters in the rectangular box a plane sheet of glass, placed in a diagonal position, which, reflecting the rays at a right angle, projects them upon the anterior surface of the screen, while the posterior surface of the screen receives the light from the other source. The eye observes the screen illuminated by both sources, one of these illuminations being by direct transmission, while the other is by diffused reflection. But to effect a comparison of the two sources it is necessary that each half of the screen should be illuminated by one of the sources alone. Accordingly, a sheet of opaque black paper is placed behind the screen covering one-half of it. This half will, therefore, receive only the reflected light, while to prevent the other half from receiving reflected light the corresponding half of the diffusible surface terminating the lateral tube is covered with opaque black paper. The subject is now required to compare the two sources of light in this manner and by modifying the aperture of the lateral diaphragm the intensity of the reflected light can be increased or diminished until a differential perception is obtained.

Another interesting instrument which is shown in Fig. 6 is the pupilometer. This is employed to determine the degree of dilatation of the pupil of the eye or the distance between the two pupils.

MOTOR OBJECTIVATION.

The somewhat technical title of "motor objectivation" includes the investigation of certain phenomena which are of vital importance in the industrial world, since by means of the tests here applied to inviduals workmen can be differentiated with respect to their specific aptitudes as well as their general capacity.

To begin with, voluntary reaction is measured, the reaction times being carefully noted. These reactions are caused by various apparatus designed to produce stimulation by means of pressure, by electricity, by heat, by sound, by light, by smell, by taste, and by pain. The reaction times are recorded by specially constructed chronoscopes.

Motor rapidity is next measured, both as regards simple movements and with respect to complex movements. Precision of movement, whether simple or complex is also carefully measured, as well as what is called motor symmetry.

An interesting division of this subject is concerned with motor suggestibility and involuntary motions. The ultimate limits of motor reactions are likewise carefully studied, together with motor inhibition.

But perhaps the most interesting branch of this subject to the average reader deals with motor fatigue and variability of effort.

THE MEASUREMENT OF MOTOR FATIGUE AND VARIABLE EFFORT.

Motor fatigue can be determined by the diminution in the intensity of movements made in a definite period of time. This diminution can be investigated as a phenomenon of fatigue pure and simple by means of an electric stimulation of the muscles. But in the ordinary affairs of life the question of fatigue is complicated by the fact that as the degree of fatigue increases it is combatted by a progressive increase in the intensity of the nerve force directed to the muscles; this, of course, naturally tends in its turn to produce a nerve fatigue which eventually causes a cessation of effort. On the other hand, it has been demonstrated by Mosso that voluntary effort tends to increase in direct proportion with muscular fatigue,

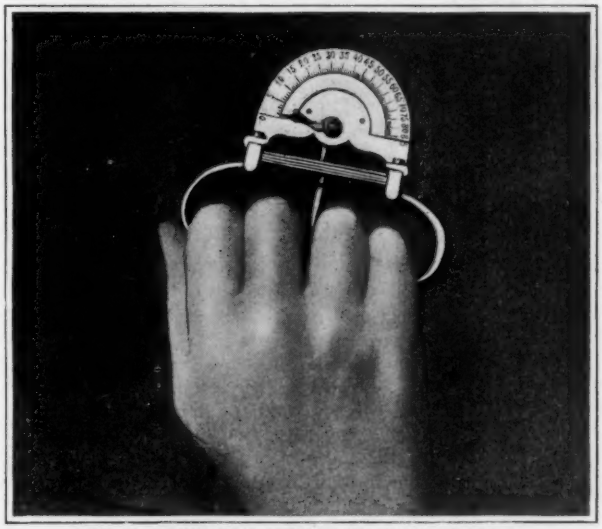


FIG. 7. REGNIER'S MUSCULAR DYNAMOMETER

a fact which most people have noted in their own experience. The investigator, therefore, in studying fatigue produced by voluntary labor seeks to determine this growing intensity of effort.

Individuals can even be classified with respect to the intensity of the voluntary effort, which they put forth in the attempt to counteract the decrease in the amount of work done due to fatigue. Such a classification carefully made would

be invaluable to an employer of labor, as well as to pedagogues. This coefficient can also be used to make a comparison beween an individual working under his own guidance, *i. e.*, a man who is being "left alone" and the same individual when subjected to the influence of various stimuli, such as admonitions, curses, prayers, the hope of reward, the fear of punishment, or the artistic delight in achievement. Perhaps this explains the well known popular assumption that only an expert in profanity makes a good mule driver.

A decrease in energy can be made by successive compressions of a dynamometer, by Mosso's ergograph, or with the dynamograph invented by Professor Charles Henry of the Sorbonne. Fatigue can also be tested by a decrease of rapidity in certain simple movements, as for example, in the so-called tapping test. This see-sawing produced by steadily increasing fatigue and by spurts of energy designed to make up for the loss causes the descending curve which indicates a fatigue to be very irregular in character, showing individual variation.

The dynamometer consists of a metal spring which is compressed by the hand. Its defect consists in its hardness and stiffness which produce pain, which tends to inhibit the effort. Mosso's ergograph is far better. In this a weight is lifted by the repeated contraction of the middle finger, which wears a ring attached to a string which runs over a pulley, the weight being at the other end of the string. The weight used must be neither too large nor too small, 3 to 4 kg. being best. The proper rhythm is one contraction of the finger every 2 seconds; a slower rate permits the finger to rest, so that according to Maggiora's ergogram a rhythm of 10 seconds prevents fatigue. Too fast a rhythm, on the other hand, tends to produce cramp. The defect of the ergograph consists in the impossibility of maintaining a sufficient degree of immobility in the arm to prevent coöperation by fresh muscles of arm and shoulder.

Professor Henry's dynamograph represents a distinct improvement. Here the work is done by compressing a rubber bulb filled with mercury communicating with a manometer. Since the mercury is not rigid the effort causes no pain. The surface of the mercury bears a float connected with a registering device. The bulb must be squeezed rather slowly to prevent the mercury from rising above the float.

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A NEW THEORY CONCERNING THE NATURE OF THE PHENOMENA OF LIFE.

BY FELIX REGNAULT.

OUR knowledge has now reached such a degree of advancement that we are enabled to regard the phenomena of life from a new viewpoint. This consists in regarding the living being as consisting of two substances, one of which is actually living while the other is organic in nature.

The living substance may be termed the "energide"; in this class are included the nucleus, the protoplasm, and certain intracellular elements. The energides manufacture organic products. Some of them remain intracellular, while others are pericellular and still others are extracellular. Among these latter are those which are architectural in character.

It is not true as stated in the classic definition that a tissue is formed simply by the union of cells having a similar constitution; it comprises also an organic product. Tissues are divided into three classes according to the quantities which they contain of this product, as follows:

1. The tissues having numerous and contiguous cells with a not very abundant intermediate organic product. Examples of such tissues are the epithelium and the endothelium. In these tissues the cell has an important functional rôle while the organic products has a secondary rôle.

2. The tissues composed of rare and isolated cells immersed in an abundant organic product. Certain lower organisms, such as the volvox are composed of cells of the same kind united by an abundant gelatinous substance. Among the higher creatures the conjuctive cartilaginous and osseous tissuer are formed in this manner. The cells of these tissues are specialized in the production of the aforesaid organic products and have no other rôle. The organic product has an important functional rôle. The grafts of these products succeed well upon condition that the cells which they enclose are killed. These dead cells are then replaced by the cells of that part of the body which acts as the host for the grafted piece and these cells readily invade the organic product.

3. Tissues constituted exclusively by the organic product. The latter proceeds from a pericellular or an intracellular secretion which is liberated by the death of the energides. Examples of such tissues are the vascular canals of wood among plants and the epidermis among animals. Finally, such a tissue is sometimes produced by an extracellular secretion, such as the shell of mollusks.

In every tissue an effort must be made to distinguish between that portion which is the truly living substance and that portion which is merely the organic product. There are cases in which this distinction is very difficult to make.

The corpuscles of the blood are living to begin with, while they exhibit a nucleus, and are erythroblasts. They continue to remain living in the batrachians among whom they retain their nucleus. But in the higher mammals they lose the nucleus and are formed solely of hemoglobin and then become merely an organic product.

The muscular substance is derived from protoplasm; from the point of view of embryologists it is to be regarded as an organic product. Protoplasm has long been regarded as the vital principle par excellence. But today it has diminished in importance, while the nucleus has increased in significance. However, the habit has continued of considering protoplasm to be a living substance as well as a nucleus. However, the properties, movement and excitability of protoplasm can be explained by physico-chemical laws. When separated from the nucleus it perishes; by itself it is incapable either of assimilation or of reproduction. Contrary to the nucleus it possesses an incomplete vital energy; to all appearance it is capable of acquiring the vital energy of the nucleus but incapable of producing that energy.

The laws which govern the phenomena of life are a subject of debate. Some authorities accept the animist theory, others that of the unicists, and still others, finally, that of the vitalists. In these discussions we ought to make a distinction between the organic products, which necessarily obey physico-chemical laws and the energies. It is quite possible that the latter produce a special form of energy which differs from other forms of physical energy as much as electricity differs from heat or from light.

Conclusion.—Living organisms may be regarded as composed of two substances, the living substance or energies and the organic product. These two substances form tissues in which they exist in variable quantities; the tissues may be classified by taking as a basis the quantity of organic products which they contain.

Certain substances which are commonly regarded as being living are in reality organic products: such are the corpuscles of the blood and the sarcolemma of the muscles. It is possible that protoplasm itself is merely an organic product of the nucleus—in any case it possesses an incomplete vital energy which it acquires from the nucleus.

While the organic products are governed by physico-chemical laws, it is easy to believe that the energides produce a special form of energy which is peculiar to life.—Presented by Dr. Ch. Richet before the French Society of Biology in Paris at the Session held December 6, 1919.

The Evolution of Efficiency in the Animal Kingdom*

The Principle of the "Shortest Line" in Action

By J. S. Szymanski, Vienna

IT is my purpose in this article to direct the reader's attention to the element of regularity found in the various activities of men and animals when regarded from the point of view of efficiency.

When we observe the various kinds of action made by men and animals, we are impressed with the fact that in most cases[1] animals as well as men act as if they meant to attain the object of their action as directly as possible, i.e., by the shortest path[2]. This principle is not immediately evident when we regard the activity of a single individual alone. The regularity above mentioned impresses us only through a comparison of a given action in different individuals or in different kinds of animals.

In order to obtain a clear perception of such regularity of actions it is advisable to make special observations under five heads, which may be stated as follows:

1. The observation of similar instinctive action in divergently constructed kinds of animals belonging to the same class of animals.

2. The observation of similar instinctive action in individuals of the same kind under different conditions of the organism.

3. The observation of similar instinctive action in the same individual and the effect of different degrees of intensity exerted by the same sort of stimulus.

4. The observation of different degrees of development of a newly acquired habit in the same individual during the course of the process of learning.

5. The observation of the execution of the same rational action by an individual at different ages.

Upon examining more closely each of these cases with respect to the question here involved, the first thing to be noticed is that in the same class of animals those kinds which are anatomically divergent perform the same instinctive action in such a manner as to make use of the principle of the "shortest path." To mention merely one example, insects cleanse their antennæ "in the mechanically simplest manner." This opinion is founded upon the following observations: as a general thing long feelers in those kinds of insects which possess masticating mouth organs, are cleansed by means of the latter; while short feelers are cleansed with the fore legs. In those kinds which do not have masticating mouth organs, both the long feelers and short feelers are cleansed by the fore legs. When, however, the masticating mouth organs are small and feebly constructed or when the feelers are comparatively stiff and inflexible even those kinds of insects which possess masticating mouth organs, cleanse their comparatively long antennæ with the legs. But even comparatively short antannæ can be cleansed with the mouth organs when the feelers have protuberances at their ends, or when the legs are comparatively short. These examples serve to show that the same action in different kinds of animals is always performed by those organs which enable the creature to perform the operation in the most direct manner, i. e., by the shortest path.

If we turn now to the observation of the same action in individuals of the same kind in different conditions of the organism, we perceive, to begin with, that when we remove some agent which is normally employed for the performance of an action, the organism is able in many cases to perform the said action with some other organ substituted as an effective agent. Thus, for example, a frog which has had some acid sprinkled on one side of the body usually wipes itself with the hind leg on the same side. But if this leg be cut off it still wipes away the acid with the hind leg on the other side (Pflueger). Or, to take another example, the red ant cleanses its feeler with the foreleg upon the same side. But if the right foreleg be amputated and the ant wishes to cleanse the left feeler, it turns its head towards the left side and seizes the left feeler with the cleansing spur of the right foreleg with which it then combs its feeler. It is quite obvious that this vicarious movement

FIG. 1. THE WING-WIPING REFLEX IN A FLY (*ERISTALIS TENANS*)

cannot be executed like normal ones along the shortest path. However, it is not necessary to remove one of the effective agents in order to exert a mechanical influence upon the performance of the action. It is quite sufficient to produce an enfeebling of the entire organism or else of the sensory activity in order to hinder the execution of the action along the shortest path. Thus it can be shown, for example, that when in an animal which is capable of making "experimental movements," we produce a heightened general mobility, through the influence of external or internal factors, it is able to move with a comparatively greater average speed in a more or less direct line either to or from the source of stimulus, arresting its progress at only a few points in order to execute "experimental movements." While, on the contrary, there has been produced in the same animal a diminished general mobility through the influence of external or internal factors, it will move with a comparatively decreased average speed either to or from the source of stimulus along more

FIG. 2. THE TRANSFORMATION OF THE STRIKING REFLEX INTO THE ROLLING-UP REFLEX

1. Striking reflex of type B (= local defense reflex).
2. During a prolonged irritation the body erects itself more and more, the legs let loose of the underlying support, the fore part of the body bends itself laterally, (3) and the caterpillar falls off the support. During its fall the caterpillar revolves itself along its longitudinal axis at an angle of 90° in such a manner that the abdominal side is made to lie inward.

or less direct paths, and will arrest its progress at many points in order to execute experimental movements.

The observations of the same action executed on the one hand by normal individuals and on the other hand by enfeebled individuals of the same kind shows that the organism operates along a shorter path when in a normal condition than when in an abnormal condition.

The impression that the organism operates along the shortest path is further strengthened by the observation of the same instinctive action in the same individual and the effect of

*Translated for the *Scientific American Monthly* from the *Biologisches Zentralblatt* (Leipzeig), May, 1917.

[1]The exceptions would be, for example, the "courtship" of animals, the crossed reflexes (Luschinger), and the cleansing of the antennae by cockroaches.

[2]In the most economic manner, therefore,

different degrees of intensity of the same stimulus. When, for example, one strokes the wing of a fly (*Eristalis tenax*) once or several times with a thread, the little creature raises the hind leg on the same side and wipes its wing with it, as if it were trying to wipe something off of the wing[1] (Fig. 1). When, however, we continue the stroking of the wing (the consummation of the overflowing excessive stimulus!) or increase its intensity, the insect flies away.

This action makes it quite evident that the whole organism does not change its position in order to escape the effect of the stimulus until the local protective reflex fails to accomplish its purpose. Still another example of the same phenomenon may be observed in the caterpillars of many butterflies (some kinds of the *Vanessa*, and *Pieris brassicae*). When we lightly touch the back of a resting caterpillar of one of these kinds with a small stick, the little creature will curve the forward part of is body backward endeavoring to reach the source of the irritation with its mouth from which there issues a drop of blood ("striking reflex of type B"). If the irritation of the back be continued the caterpillar either moves away or else the striking reflex passes over into an incomplete rolling-up reflex and the caterpillar falls down off its support. This is the case also in which the local defence reflex passes over into a general flight reflex. It indicates that the organism first attempts to get rid of an injurius factor by the shortest path and does not attempt other action until the first fails to be successful.

This regularity of action is especially evident in the process of learning. The observation of the different degrees of development in a newly acquired habit in the same individual during the course of the process of learning shows that the animal or the human being constantly selects the shortest path during the progress towards perfection in the execution of the action concerned until finally, when the process of learning has been perfected, the action is executed

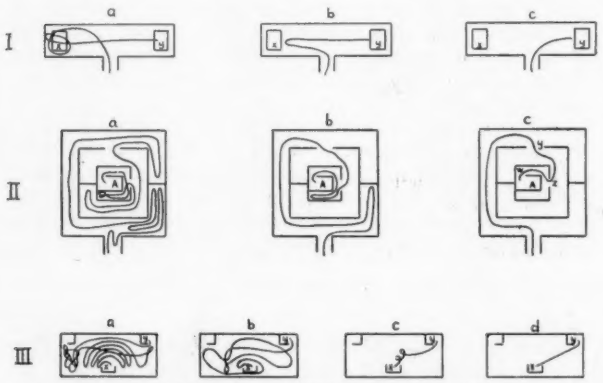


FIG. 3. BEHAVIOR OF ANIMALS IN A LABYRINTH

I. Behavior of a gold-fish in a labyrinth at the beginning of a series of experiments (*a*), during its further progress (*b*), and at the conclusion (*c*). *x* = a closed exit, *y* = an open exit.

II. Behavior of a rat in a labyrinth at the beginning of a series of tests (*a*), during its further progress (*b*), and at the conclusion (*c*). The dwelling cage and food are located at A; y z w represents the shortest path from the front of the enclosure to A.

III. Behavior of a dog in a testing space at the beginning of the series of tests (*a*), during its further progress (*b*, *c*) and at the conclusion (*d*). The front of the enclosure is at *x* and the food is at *y*. In all the figures the heavy lines represent the path taken by the animal.

along the shortest path. Herein lies the principle of learning through the elimination of unnecessary movements or in the well-known phrases of an American authority: "The dropping of useless movements."

[1]Among all the kinds of flies which I tested in this manner only the *Eristalis* exhibited this reflex. It is easiest to slip up on this fly without startling it when its reflexes of forward motion have been made sluggish through some local condition, such as the weather (a rainy day) or the coming of twilight (the beginning of the period of nocturnal rest).

As an example of this I will mention merely the process of learning to peck in chicks (Morgan, Breed) and the behavior of animals during the process of becoming accustomed to find their way out of a labyrinth (Fig. 3). Learning through the elimination of superfluous movements is especially fitted to show clearly that when the process of learning has been completed the given action is accomplished along the shortest path. Finally, when we regard the accomplishment of the same rational act in a single individual at different ages, it becomes evident that in the earlier years of life such actions are not accomplished in a perfectly rational manner, i.e., they are not performed by the shortest path. It is only with advancing age that the individual performs acts in a thoroughly rational manner, i.e., along the shortest path. By way of an example I would call the reader's attention to the

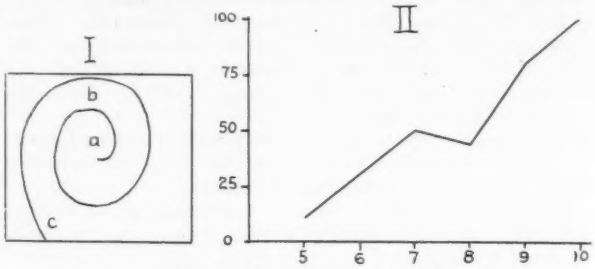


FIG. 4. TEST OF CHILDREN IN A LABYRINTH

I. The labyrinth in the shape of a snail shell.

II. The curves are intended to make evident the capacity for rational action as shown by the labyrinth sweeping test. The cases in which the child acts rationally, *i. e.* in which it begins to sweep at *a* are shown upon the ordinate (in percentages), while the age in years is placed upon the abscissae.

results of the so called "sweeping the labyrinth test." This test consists in the removal of bits of gravel from a labyrinth in the form of a snail shell (Fig. 4-I).

It was found that children did not perform this act rationally, i.e., did not begin the sweeping at *a* until they had reached the age of about nine; children from five to eight years of age, inclusive, did not act rationally, since they began to sweep at *c* or *b*. The rational action only is a perfected action since it is performed along the shortest path. As this example shows, the development of rational conduct progresses with advancing age in the direction of the performance of a given act by the shortest method.

The perfecting of behavior in adults and also in successive generations of mankind follows the same direction. For thorough scientific researches, *i. e.*, through the process of learning, successive generations eliminate the irrational manner of conduct of their ancestors (consider, for example, the psycho-technical principle of the scientific management of business). In this case a similar process takes place, so to speak, to that which we have observed in the progress of learning through dropping useless movements. Consequently the aforesaid regularity is to be discovered by the observer in all types of action!

OZONIZING POWER OF SOLAR RADIATION AT HIGH ALTITUDES.

As a result of experiments at Mont Blanc Observatory to determine the part played by the solar radiation in the production of atmospheric ozone at a high altitude, it is shown that at an altitude of 4,360 meters the solar radiation has no ozonizing power, and that the ozone found in the middle and lower atmospheric layers is not formed there by the direct and local action of the sun. The therapeutic effects of the sunbath cure cannot, therefore, be attributed, as has been hitherto imagined, to a chemical process of this nature.—*Comptes Rendus*, Nov. 24, 1919. Abstracted by *The Technical Review*.

Human Grafting

The Brilliant and Successful Experiments of Dr. Serge Voronoff

By May Tevis

OUT of the monstrous evil of the war is it comforting to reflect that at least some good has come in an enormous stimulous given to medical science and surgical skill. Nowhere is this more marked than in the marvels of human grafting, which have performed actual miracles for countless wounded, crippled and disfigured men.

A well-known European surgeon, Dr. S. Voronoff, formerly a pupil under the famous Dr. Alexis Carrel of the Rockefeller Institute, and himself the author of the valuable work, a "Treatise Upon Human Grafting," contributes to a late number of *La Revue* (Paris), an article upon this vitally important subject. He says: "It is evidendy not sufficient that the human grafting should exhibit good results for a limited time only; it is necessary that the result should be durable, and that the transplanted organ should give rise to no trouble in the new organism. On my return from New York in 1910, where I followed the work of Dr. Carrel, I undertook certain experiments in order to determine the conditions which might insure the definite vitality of grafted organs. I soon perceived that the organs borrowed by one animal from another of the same species sometimes exhibit signs of retrogression and atrophy. I concluded that the borrowed organ failed to find the proper vital conditions and nutritive environment in its new host necessary for its continued existence. Every living being represents a highly personal individual entity, possessing a peculiar temperament and blood character, which, while similar to that of other individuals of the same species, nevertheless has certain peculiarities which defferentiate the intimate biological conditions of the cell life in our organs. This indivdual difference varies in degree, and it occured to me that it must certainly be possible to find some individuals which were more closely similar than others among the same species. I based this opinion upon the fact that some individuals are found whose blood when mingled forms a uniform liquid wherein it is impossible to distinguish the portions coming from one or the other. There are others on the contrary whose blood immediately coagulates in contact with the added blood, and there are still others whose blood acts like an acid upon the blood which is poured into it, dissolving and destroying the red corpuscles. An organ borrowed from an individual whose blood is very different from that of the individual in which it is planted is naturally certain to die, since its nutritive environment is suddenly changed. On the other hand when the transplanted organ finds the same conditions which governed its previous life it continues to live in a normal manner. The success of the grafting depends therefore upon the affinity of the two creatures, upon the type so to speak to which they both belong. These ideas naturally led me to the conclusion that this affinity would be found especially among the members of the same family. In place therefore of selecting animals at chance, I undertook a series of experiments between related animals; these experiments were made at the Clinique Sainte-Marguerite, where I was assisted by Prof. Hobbs, Dr. Montalti and Dr. Rosanoff, and the Veterinary Surgeon, Buqueux. My first subjects were sheep, selected because shepherds are commonly very familiar with the relationship of the animals and their flocks. I had the immense satisfaction of finding my hypothesis confirmed by these experiments, and in 1912 I was able to present before the Congress of Surgery, held in Paris in 1912, transplanted organs exhibiting perfect vitality at the end of two years. In 1913 I was able to give a convincing demonstration of the truth of my theory by exhibiting at the International Congress of Medicine a lamb which has been conceived by a ewe, whose reproductive organs had been transplanted from her sister sheep after her own had been removed.

"Since the conditions of successive grafting even of complex organs has thus been demonstrated, the biological affinity should always be sought for, either in members of the same family, or in individuals not related, but in whom biologic affinity has been detected by the examination of the blood. It is obvious that success is still more certain when it is possible to take the graft from the individual itself since the transplanted organ then continues its existence without the change of previous conditions of life."

Having thus proved his theory by animal experimentation Dr. Voronoff proceeded to undertake human grafting. Shortly before the outbreak of the war he reported to the Academy of Medicine in Paris a remarkable case wherein he improved the condition of a child who was idiotic because of the atrophy of the thyroid gland by grafting upon it a thyroid gland of a monkey, and a still more remarkable case where he grafted a portion of a thyroid gland of a mother upon her son with remarkable results. The latter, a youth of twenty, resembled a child of ten in appearance, having been born without a thyroid gland. He had remained small, fat, with a neck sunken in his shoulders and the cretinoid face which recalls an animal. This boy, dull and apathetic, able to pronounce only a few intelligible words, and hiding in corners like a frightened animal, presented a painful contrast to his brother only a year older, but a big vigorous fellow fighting bravely at the front. In 1915 the mother, a strong and intelligent woman, gladly consented to have a portion of her own thyroid gland removed and grafted upon her son. The operation was highly successful, and at the end of a year an absolutely marvelous change was found in the afflicted youth. He had begun to grow, gaining sixteen centimeters (over 6 inches) in the year, his head was no longer sunken between his shoulders. The bloated look had disappeared; best of all his mind had been awakened. He was able to talk distinctly and he is at present earning his living by working in a bakery.

Dr. Voronoff says further: "These facts, together with many others of a less general character, such as the transplantation of foetal membranes, which I employed to restore the skin, and the facts published by Delbet, Tuffier, Walther, Vuttner, Lexer, etc., contributed to create favorable opinion toward the project of enabling our wounded men to profit by this new acquisition of science. In December, 1914, four months after the beginning of the war, the 'Service de Santé,' created at the Russian Hospital in Bordeaux, of which I was then in charge, a section of osseus grafting. The hospitals of the eighteenth Région were invited to send to this section all their wounded men suffering from lesions accompanied by loss of bone. Later in June, 1915, when the 'Service de Santé,' with the assistance of the generous philanthropist, N. de Spoturno-Coty, had created a hospital especially devoted to grafting, Auxiliary Hospital No. 197, and Paris hospitals were likewise invited to send there such wounded men as might be assisted by grafting. I therefore received a large number of men having wounds of this description, wounded men whom my colleagues had been wise enough not to subject to amputation even in cases where arms and legs were hanging like rags. In this new surgery there was still much investigation to be done as to the best instruments, process, operative conditions, etc. In times of peace the surgery of grafting was of too recent a date and its field was too narrow to have been fully systematized. The only subjects which had been conceived by a ewe, whose reproductive organs

those sufferings from tumors of the bones, and even in these cases the employment of grafting was very exceptional since the minds of surgeons were still imbued with the ancient ideas which inclined them to practice amputation whenever the continuity of the bone was interfered with for a considerable length. The first problem is to decide where to take the graft; as I have said, it is necessary that these grafts should find the same nutritive environment, and the same biological conditions in the new host, which they previously had. When the wounded man is able to bear it, the best thing therefore is to take the needed fragment of bone from his own body. At first the idea seems paradoxical, since the

FIG. 1. FRACTURE OF THE UPPER THIRD OF THE LEFT TIBIA (SHIN BONE) WITH A LOSS OF 4½ INCHES OF BONE

Entered hospital 40 days after receiving wound, his leg being immobilized in a plaster cast.

proposition is to repair a fractured leg or arm by breaking another bone of the wounded man. Happily the reality is less tragic than it seems. Nature has thoughtfully given us a bone which we can dispense with, without suffering any inconvenience. This is the fibula, that thin but solid bone which is able to bear a weight of 70 kilos (154 pounds) without breaking, and which is fastened to the tibia. Our body is supported by the femur which is joined directly to the tibia and not to the fibula, which we retain as a vestige of an ancestral condition, and which we can dispense with without trouble, at any rate without its upper part. Moreover, there are many animals which are excellent runners and yet do not possess this bone. When taken from the invalid himself this bone naturally finds the same vital conditions to which it is accustomed, and it is grafted with great ease in the new area to which it is tranplanted. Placed between parts of bones which are larger than itself, such as the femur or the tibia, it not only welds the broken parts together but it becomes larger itself, becoming indeed almost as large as the femur or tibia, thanks to the more abundant nutrition which it receives from the bigger blood vessels in its new position, and thanks also to the marvelous adaptability of every organ to its new function. This growth in volume naturally requires a certain length of time, sometimes a year or longer. But this bone is not the only one which can be used as material for grafting. The graft is often borrowed from the tibia, by cutting a piece of a certain thickness out of it, especially to repair an arm bone. The tibia is such a thick bone that it can stand such a loss without injuring its solidity; in fact, the wounded man who has had a piece of bone borrowed from his leg to mend his arm is able to get out of bed and walk without trouble ten days after the operation. In other cases I have borrowed a boney fragment to fill in a fractured bone from the longest fragment of the injured bone itself, and in my 'Treatise Upon Human Grafting,' in which I have described the development of grafts in various wounded men, there are radiographs and photographs of the patient to whom I applied this process with perfect results. I have found that the 'autograft,' that is a fragment of bone borrowed from the patient himself always gives excellent results in certain conditions. It is quite possible to graft bone taken from another individual or even from an animal, but under such conditions the result is less certain."

Dr. Voronoff even makes the startling statement that it is quite feasible to borrow bones from dead men to mend those of the living, since the death of the individual through the stopping of the heart and the cessation of the circulation of the blood does not cause the immediate cessation of life in all the organs. These continue to live for a certain length of time before decomposition sets in, the period varying with the delicacy of the structure. Dr. Voronoff states that bone survives for eighteen hours after the general death and when removed before this time has expired, it retains all the properties of the bone cut from the living individual, and may be used to repair fractures in the wounded man. He says:

"Bones of animals can likewise be employed, and some ten years ago I was able to transplant a piece of bone cut from the shoulder blade of a sheep under the influence of chloroform into the skull of the patient whose occipital bone had been partly destroyed by a tumor of the brain. After removal of the tumor the breach in the bone was filled in in this manner, and six months after the operation the skull was in perfect repair. In this case, however, I was able to prove that the sheep bone did not form a true graft upon the human bone, but that it was little by little dissolved and absorbed; but as fast as the cells of the sheep bone disappeared they were replaced by osseus cells coming from the human bones in the midst of which they had been implanted. The bone of the sheep, therefore, served merely as a scaffold which the human bones made use of in order to construct the now bone. It is possible, therefore, to make use of the bones of animals as a provisional living substance in order to form a sort of bridge between human bones, by means of which the cells of the latter may eventually join each other and become solidified."

It is very important, however, says the surgeon, that the tissues should be healthy in order to secure the success of

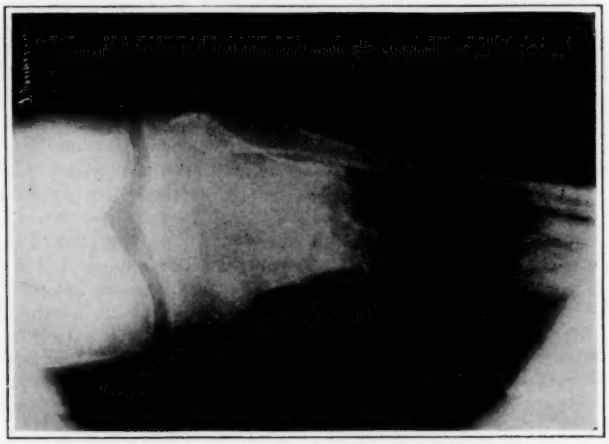


FIG. 2. X-RAY PICTURE OF FIG. 1 SHOWING LOSS OF BONE

the graft. Unfortunately, wounds received in battle are always infected, and while in this condition the transplanted fragment of bone will itself begin to suppurate, hence no attempt at grafting should be made until the wound is completely healed, and there is not the slightest particle of pus remaining. Even so the graft cannot be undertaken immediately since it has been proved that even the healed wound retains within its depths for several months thousands of latent microbes, which are capable of being revived and producing fresh suppuration if the old wound is opened too soon. Dr. Voronhoff states that his experience has shown that it is necessary to wait from eight to twelve months on an average after the wound has been healed before attempting the graft.

It is also very important that the transplanted bone should be placed within the breech without the help of any foreign body, such as metal plates, wires or hooks. This is done by cutting the transplanted piece longer than the breach to be filled and splicing its ends into the ends of the broken bone. By proceeding thus excellent results are obtained. Dr. Morestin, who specializes in wounds of the face, has obtained really remarkable results by the grafting of bone and cartilage taken from the ribs, thus rebuilding broken jaw bones, and replacing the bones of the nose and eye sockets, etc. Skin grafting is also frequently practiced among wounded men who have suffered the loss of large areas of skin. Without skin grafting many months would be required for the healing of such wounds, and the wound would then be covered with thin hard scar tissue lacking the flexibility and elasticity of the true skin. Moreover, said scar tissue often produces retraction of the limbs, giving them awkward and painful attitudes, or it may press upon the sensory or motor nerves in such a way as to cause inertia or interfere with the movement of the limb. Skin grafting on the contrary enables the surgeon to produce a smooth flexible perfect cutaneous covering in a comparatively short time. Dr. Voronoff has made use of skin grafting particularly for covering the stumps of legs which had been amputated in the ambulance. Such amputation is often done by the blow of an axe, leaving the stump quite uncovered by skin. In such cases after several months of suppuration the stump is covered by a thin and uneven layer of skin tissue, which is very senstitive and badly adapted to support an artificial limb. By means of skin grafting these large wounds can be completely covered with supple thick colorless skin in two weeks or less.

Dr. Voronoff states that he has not yet made a graft of a joint, although there are many cases where wounded men have had the joint entirely destroyed, and where the use of the limb might be saved by the transplanting of a joint from a recently deceased corpse. But since such an operation would be unusually delicate and difficult, it is necessary to experiment upon animals before attempting to practice upon human

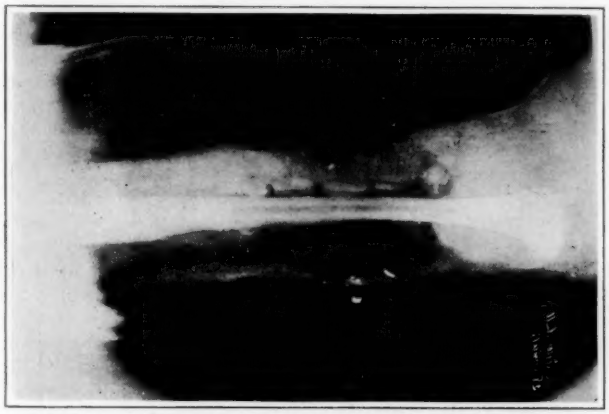


FIG. 3. X-RAY PICTURE ONE MONTH LATER, SHOWING AUTOGENOUS GRAFT TAKEN FROM TIBIA OF THE RIGHT LEG

subjects. A very large number of such experiments were made by Dr. Voronoff during a period of a year at the Physiological Station of the Collége de France, and were described by him before the Biollgical Society of Paris. Dogs which had had a new foot joint grafted on were able to run, walk and jump six months later without anything to indicate that they had a new joint instead of the original one. On examination the articulations were found to be quite supple and well nourished by the blood vessels of new formation. The cartilage was flexible and movement perfect. "These happy results permit us to hope," says the surgeon, "that we might benefit our wounded men in similar manner. But none of these grafts, whether of bones, joints, skin, tendons or nerves, can be applied on a large scale until after the war, since, as I have stated, the wound must be entirely free from ancient septic centers. Moreover, these grafting operations should be undertaken only in hospitals into which patients with suppurating wounds are not received. Since the transplanted fragments have diminished vitally until they form the proper connection with the blood vessels of the new organism, the slightest infection will cause them to die."

While there are many thousands of men crippled by the war, this eminent surgeon holds out the glorious hope that

FIG. 4. RESULTS OBTAINED, SHOWING SCAR OF VORONOFF'S INCISION

a large majority of them may be restored to active life by such operations as he has here outlined. He says finally:

"During the war the most urgent cases only can be treated. Above all the lives of the wounded men must be saved; but after the war it will be our task to restore those men to health and usefulness. Ten years of continuous effort will be necessary to combat and modify the subsequent effects of wounds. Functional re-education and physiotherapy will certainly be of great service, but it will be grafting which will be most important of all. Bones will be grafted on to reconstruct jaws and eye sockets, and to make legs and arms serviceable; jaws will be grafted on to replace those which have been destroyed; skin will be grafted on to remove the disfiguration due to scars; tendons will be grafted to remedy contraction of the fingers; nerves will be grafted to cure paralysis of the limbs, and teeth and hair will be grafted to re-establish the harmony and beauty of the organism. Modern science can and must be bold enough to undertake this task. Humanity in its ascending evolution acquires new creative forces, and we shall become more and more the masters of our own bodies."

CURING SPANISH INFLUENZA WITH TURPENTINE.

THE so-called Spanish influenza whose ravages have been general in America as well as in Europe, and which is said to have claimed more victims among our own troops than all the deadly missiles of the enemy, has naturally been a subject of much discussion among medical men the world over. As usual the doctors do not always agree. In a report read before the French Academy of Medicine, Dr. Bezançon made the statement that the pneumococcus is the microbe principally concerned. A fortnight later (August 27, 1918), Dr. Orticoni and Dr. Antoine declared before the same body that in a certain grave cases, at least, the present epidemic may be regarded as a new malady, characterized by the presence in the blood of a peculiarly resistant variety of Pfeiffer's bacillus. Since Dr. Orticoni is the director of the laboratory of epidemology in the French Army, and Dr. Antoine's office is that of consulting physician, they are probably correct as to the most fatal form of the disease. It is gratifying to learn that a new and simple form of treatment has been marvellously successful in curing the most severe and apparently hopeless cases. This treatment consists in the injection of

a few cubic centimeters of pure turpentine into the flesh of the patient. Solid masses of muscle, such as the thigh or the calf of the leg are selected for the operation. The immediate effect produced by the turpentine is the appearance of large aseptic abscesses which cause a so-called "fixation" of the deadly germ. Whatever the mechanism of the curative action of the turpentine, the results are said to be truly marvellous.

Strictly speaking the remedy is not new though the present application is a fresh revival. According to Francis Marre, writing in *La Correspondence* (Paris), Professor Fauchier of the University of Lyons made a practice of the systematic injection more than twenty-five years ago of turpentine into the thigh or the calf of patients suffering from serious cases of pneumonia or septicemia, explaining to the students who atended his clinics that he did this for the purpose of causing the formation of aseptic abscesses of fixation or of derivation.

HOW AGE AFFECTS THE RESPIRATION OF LEAF CELLS.

A FRENCH botanist, M. Maurice Bézagu, has recently been making some studies of the interchange of gases or "respiration" of the cells of leaves and has made the interesting discovery that this process is affected by the age of the leaf. At the meeting of the French Academy, September 22, 1919, he made the following report of the results of his researches upon this question:

The various plant physiologists who have devoted themselves to the study of this question have reported the respiratory intensity of the carbon dioxide liberated during one hour, as being equal to 1 gr. of "cool" weight. They have thus proved that the respiratory activity steadily decreases as the leaf develops. The same thing is said to be true of the ratio $\frac{CO_2}{O_2}$ of which M. Nicholas has recently made a study (*Revue Générale de Botanique*, Vol. XXX, No. 335, 1918).

I have undertaken in my own researches to report the respiratory intensity, not in the gram-hour, a purely physical unit, but in the physiological and histological unit, the cell, during its respiration for a period of one hour. To this end I have related the respiration to the organ-hour, previously formulating the following hypotheses:

1. Two adult leaves of the same species and having surfaces practically equal possess the same number of cells.

2. This number is the same as that of the young leaves which have not yet attained their final dimensions, but in which cellular division has completely ceased. This latter supposition may be regarded as highly probable if we confine our observations to species in which it has been shown that the leaf develops very regularly and reaches, as a general thing, an area of surface which is practically always the same when in the adult state.

I have taken as the subject of my experiments the leaves of the *Robinia pseudacacia*, *Pinus silvestris*, *Coboea scandens*, *Ligustrum vulgare*, *Althoea*, *Loroglossum hircinum*, *Cercis siliquastrum*, and obtained the following results:

1. The respiratory intensity of the cell, which is very slight in the young cells, steadily increases up to a certain maximum which corresponds practically to the moment when the leaf attains its full development; as the leaf ages the respiratory intensity gradually decreases.

Thus at 28°C. a leaf (having six leaflets) of *Coboea scandens*, weighing 0.105 gr. liberates 0.147 ccm. of carbon dioxide; an older leaf, weighing 0.995 gr., liberates 0.499 ccm., an adult leaf weighing 1.757 gr. liberates 0.548 gr., and finally an old leaf, weighing 1.512 gr., liberates only 0.453 ccm. The quantities of oxygen absorbed equal respectively 0.143 ccm., 0.626 ccm., 0.703 ccm., and 0.629 ccm.; these figures form a curve of the same outline as that which represents the carbon dioxide with the maximum at the same age.

In the same way two opposite leaves of the *Ligustrum vulgare* taken at different nodes liberate in a single hour the following amount of carbon dioxide; for a weight of 0.047 gr. 0.014 ccm., for 0.440 gr. 0.119 ccm., for 0.860 gr. 0.218 ccm., and for 0.972 gr. 0.186 ccm.

In relating these results to the gram we are able to verify the known results, namely, that the respiratory intensity decreases with age.

2. The respiratory quotient of leaves, which is very slight when they are young increases very rapidly up to a maximum; then it decreases very slowly until the adult state is reached; and finally, it continues to decrease regularly after the leaf has attained its final dimensions.

Thus in my experiments with the *Robinia pseudacacia* $\frac{CO_2}{O_2}$ starting at 0.60 increases up to about 1 (in one case it was 1.04 and in another it was 0.99), then decreases by very slight amount for leaves taken at successive modes.

The *Loroglossum* shows the same rate of progress but the maximum is only 0.68 while in the *Ligustrum* it is 0.84.

It is evident, therefore, that there is a maximum in the variation of the respiratory quotient, a result which had not hitherto been shown by any authority. There are doubtless two reasons for the failure to note this fact on the part of previous observers—in the first place they failed to experiment with leaves sufficiently young, whereas it is only the very young leaves in which it is possible to observe the abruptly ascending portion of the representative curve; and secondly, investigators have ordinarily conducted their experiments upon only two classes of leaves—young leaves and old leaves, thus having only two points of observation in each series of experiments, a number insufficient to determine the curve.

It should be noted that the respective maxima of the intensity and of the respiratory quotient correspond to very different periods in the evolution of the cell; the first, in fact, is attained by the foliary cells which have fully reached the adult stage, while the second is manifested in very young leaves, in the bud, or shortly after the opening of the latter.

SUGAR AND ALCOHOL FROM THE NIPA PALM.

THE *Bulletin of the Manila Bureau of Sciences* has recently published an interesting account of the possibilities for the production of sugar and alcohol which reside in the Nipa palm which grows in marshy territory and near the mouths of rivers occupying vast areas in the vicinity of Manila Bay and along the coast of other Philippine provinces. The leaf of this palm is used for roofing the huts of the natives, while the fruit is eaten either raw or preserved.

No incision is made in the tree until it has reached the age of five years. The juice is then collected through a period of six months, from July to December, in bamboo tubes holding two liters each. It is estimated that 86,000 liters of juice per hectar can be collected since one hectar will grow 2,000 trees, each yielding about 43 liters. From this amount of juice the minimum yield should be 5,000 liters of 95 per cent alcohol. According to the Far Eastern Review, Mr. Gibbs, a chemist associated with the Bureau of Sciences, predicts a most important commercial future for both the alcohol and the sugar made from the nipa palm.

In the present state of affairs the sugar which can be produced from the nipa is, perhaps, of the greatest interest. In tests made at Manila by Mr. Gibbs, 4 liters of nipa juice subjected to suitable chemical processes, yielded 236 gr. of sucrose, which after boiling and drying produced white crystals of excellent grain weighing 157 gr. and polarizing at 96.8. The molasses upon being boiled yielded 79 gr. of yellow sugar polarizing at 93.8. The second molasses of the same color, measuring 29 ccm., polarized at 58.6. These results in Mr. Gibb's opinion make it certain that the nipa will prove a profitable source of sugar. He estimates that the cost of refining should be considerably less than with sugar cane. Other tropical plants of value, though in a less degree for the production of sugar, alcohol and vinegar are the cocoanut, the buri palm and the sugar palm.

The Arts of Imitation Among Animals

How Far Are They the Product of Instinct and Observation?

EVERYBODY has observed the amusing manner in which young animals imitate their elders. Such imitations suggest the query as to how far they are the product of instinct and to what extent, on the other hand, that of observation. In a recent number of *La Nature*, M. Henry Coupin collates some entertaining examples to show that the latter faculty is frequently employed among various animals. He says:

An excellent method of studying the principle of "imitation" is quite simple, consisting merely in the rearing of certain animals by parents belonging to another species, and then observing the degree in which the behavior of the young ones varies from that which is their by heredity. For example, everyone is familiar with the graceful gesture with which cats lick the paw and then pass it over the face. No similar gesture has ever been observed in dogs. However, puppies which have been suckled by a cat act in the same manner and even borrow various features of their behavior from the male cat. This fact was noted many years ago by Audouin and has since been confirmed by many others. Durau Malle speaks, for example, of a terrier belonging to him which had been raised from the time of its birth with a young cat some six weeks older than itself. Until it was two years old the terrier was not in the company of any other dog and during this time it was accustomed to jumping like a cat, to rolling a ball, to playing with a mouse with its forepaws, to licking its paws, and to scratching its ears. Moreover, it appeared to dislike animals of its own species, and if a strange dog came into the garden where it was it chased the latter promptly away. Another observer, Prichard, also mentions a dog which had been raised by a cat and had been taught by its foster-mother the art of licking its paws and washing its face. Dr. Routh also cites the curious case of his own dog, a King Charles spaniel, which had been suckled and reared by a cat from the third day of its birth. Like the cat the spaniel was afraid of rain and would turn aside from its path to avoid a damp spot in the road. It sat upon its tail as cats do, licked its paws two or three times, and then washed its muzzle with them. It would likewise remain for hours together on guard at a mouse hole. . . . Another lover of house animals, C. H. Jeens, tells of his dog which had been nursed by a cat from the time it was a month old, and which not only was in the habit of killing mice, but what is far more curious treated them in the same manner, letting them escape and then recatching them repeatedly for several minutes.

Schleitlein speaks of a spaniel which was in the habit of closely watching its master with the evident desire to render him a service . . . ; if his master picked up a ball to play at skittles, the dog likewise seized one and seemed chagrined at being unable to bite it. When his master collected stones for his collection the dog also picked up pebbles. If the master began to dig the dog promptly followed suit with his paws. When his master sat at a window to gaze upon the view the dog leaped up beside him and likewise gazed out. When he saw his master or the cook carrying a stick or a basket the dog made known his desire to do the same.

K. Groos considers it to be evident—though the matter is disputable—that there is a certain quality of imitation in the howl of a dog which listens to music. "It should be noted," he says, "that a dog who accompanies a piano with his howls is not always forced to listen to the music, but remains in the room of his own accord. I am very far from believing that the howl of the dog is always a sign of displeasure—as a matter of fact it is just at this time, that is, when he accompanies the music with his howl that it seems to me that he uses his voice with the most pleasure and zest. One might also mention certain isolated cases in which there may be thought that there was even an imperfect imitation of the air. However, it is easy to be the victim of an illusion as regards this. One of my friends, the curé A. Freiber, living near Eppingen, possessed when a student a female spaniel, named Rolla, which he was accustomed to exhibit to his friends. When, for example, he sang the Lorelei in a falsetto voice the dog accompanied the air with howls and one soon became able to perceive quite plainly that the voice of the dog followed the varieties of the tones in some degree. . . ."

The spirit of imitation is still better developed in monkeys . . . examples of this are abundant. We will cite one which is not very well known, related by Fr. Elleendorb, concerning a small black monkey with a white head from Costa Rica. "The first day that he was in the room, he seated himself in front of me at the table and examined everything he found. He finally came across a box of matches which he soon succeeded in opening. He smelt them and threw them upon the table. I picked up one, lit it and showed it to him. He opened his small eyes wide with astonishment and gazed at the flame fixedly. I lit a second and a third and handed them to him. He held out his hand hesitatingly, took hold of the match, held it before his face and gazed at it with astonishment. When the flame came near his fingers, he threw the match down. I closed the box and put it upon the table thinking he would immediately take possession if it. But he seated himself opposite it and looked at it and smelt it from all sides without daring to touch it; then he approached me, rubbed himself against me and made signs full of astonishment as if he said "What is that?" He next returned to the box, turned it every which way and finally succeeded in opening it, but carefully avoided touching the matches. He seemed anxious and doubtful, walking around the box, and then returning to me as if to make some inquiry. I lit a match and handed it to him. When it had burned out he took one himself, scratched it upon the cover of the box, and turned the latter upside down. Shortly after he turned the box over again with the prepared side on top and scratched another match, but since he had seized the match from the wrong end I turned it for him; he then began to scratch it on the box until it caught fire whereupon he exhibited great joy and excitement. He thereupon seized a handful of matches and scratched them upon the cover until they lit."

Romanes' sister tells another story worth quoting with regard to a brown capuchin monkey. "One day when he had broken his chain he went up to a box in which nuts were kept for him, looked for the key and fingered the lock, whereupon I handed him the key. For the next two hours he tried to open the chest, but the lock was a little bit strained so that in order to open it it was necessary to lean on the cover; for this reason I thought it would be impossible for the monkey to open it. He finally succeeded in getting the key into the keyhole, turned it in both directions and after each attempt endeavored to lift the cover. All this was evidently the result of his observation of human beings as is shown quite plainly from the fact that after each failure to get the box open, he fumbled about the lock for a number of times with the key. This is explained by the fact that my mother, owing to her poor eyesight, was obliged to fumble with the lock a number of times before being able to insert the key. The monkey evidently believed that this fumbling was indispensable, though it was quite useless so far as he was concerned, as he was perfectly able to insert the key in the lock.

Among other examples of imitative acts might be cited sheep . . . elephants (in which case domesticated animals are employed to educate wild captives), many bears, martens, parrots, etc.; but the instances given above are sufficient to call attention to the matter and engage the interest of the observer.

Artificial Parthenogenesis and Cell Stimulants*

Similarity Between the Regeneration of Wounds and the Phenomena of Reproduction

By Prof. Dr. Methodi Popoff

The author of the present article is a well-known authority upon cell study. At the time of writing in February, 1916, he was one of the physicians on the staff of the Bulgarian Military Hospital No. 1, at Skopje in Macedonia. Through a coördination of the observations here made by him upon the wounds of soldiers with the results of his previous study of the functions of the germ-cells and the somatic cells and of the phenomena of parthenogenesis, he came to the remarkable conclusion that the regeneration of wound tissues is similar in character to the regeneration of the germ cells, which results in reproduction. He furthermore declares it to be his belief that in both cases, i. e. in the regeneration of the somatic cells as well as that of the reproductive cells the same cause is operative, namely, the stimulation of the cell. In the present study he gives a masterly resumé of the work done by such eminent authorities as Loeb and Delage with respect to artificial parthenogenesis, adding thereto a description of his own experiments and observations by means of which he was led to the profoundly important conclusion that all cells whether the somatic tissue cells of the individuals or the reproductive cells, and whether animal or vegetable, are alike subject to the same law of periods of depression and can alike be aroused from such depression by means of a great variety of stimuli.—EDITOR.

THE close observation of the life processes of the free-living cells has made known to us peculiar conditions occurring therein under which the physiological functions of the cell undergo a disturbance—coming indeed to an almost complete cessation of function—and then after the lapse of a certain period of time resuming their normal course. These conditions of retarded functioning—the conditions of depression as they have been strikingly called by Calkins—are particularly easy to perceive in the protozoa (Maupas, Hertwig, Popoff, etc.) just before the commencement of the sexual processes. The latter usually begin to make their appearance precisely during the period of the so-called "senile degeneration" (Maupas) of the cells, in other words, the period of a physiological depression (Hertwig). Through the beginning of the sexual processes or else through other regulating processes, the cells suffering from depression are rejuvenated and have their vital capacity restored.

Starting from this basis I have expressed the opinion in a number of publications that the aforesaid physiological condition is not only characteristic of the free-living cells, but also of the sexual cells of the metazoa, *i. e.*, that the cells of all those organisms of a higher order than the protozoa are also subject to a similar physiolgical depression. As a matter of fact when we examine more closely the processes of development of the sexual cells, or germ cells, of the metazoa, we are immediately struck by the fact that after a series of complicated alterations the germ cells finally arrive at a peculiar physiological condition, in which condition there is a disturbance of their vital processes. This disturbance finally becomes so great that the sexual cells, even under the most favorable conditions, finally and inevitably perish. The sexual cells die through the mere alteration undergone by every cell of the organism which has ended its course of life; in other words, the sexual cells perish through a profound physiological depression.

The exception of this vital process of the germ cells exhibited by the normally parthenogenetic ovules or "eggs" is only *apparent*. It is true indeed that such eggs exhibit great tenacity of life throughout an entire series of generations, since they constantly produce new generations without the intervention of the regulating process; however, even in the case of these cells conditions finally arise which cause them to be incapable of further spontaneous development. When they arrive at this phase of their development they die, by reason of a profound physiological depression, in the absence of any regulating process.

This course of the life of the germ cells—whether they be protozoan cells, differentiated sexual cells of the metazoa, or normally parthenogenetic egg-cells—indicates that these cells, exactly like the somatic cells of a many-celled organism are subject to conditions of depression, which in the absence of regulating processes result in the degeneration and the death of all these cells.

One of the regulation processes which normally makes its appearance in the sexual cells is fertilization. When fertilization occurs the germ cell whose death is otherwise inevitable receives an impulse to evolution, and thus by reason of its latent potentialities gives rise to a new organism.

At the present time, however, we are familiar with cases in which egg-cells which normally require to be fertilized become capable of development without any previous fertilization. The name of artificial parthenogenesis has been given to such phenomena. It has been proved by numerous observations and experiments that the regulating physiological effect of fertilization can be almost entirely replaced by an extremely large variety of agents and that by such means those cells which are in a state of profound depression can be made once more capable of life and development. This brings us to the crux of our present question. Hence I will here develop somewhat further the ideas expressed in my volume entitled "*Experimentellen Zellstudien* IV."

In 1886 Tichomiroff treated unfertilized *bombyx* ovules for a period of two minutes with acids such as hydrochloric and sulphuric acid or with purely mechanical stimuli such as friction, agitation, etc. The ovules thereupon began to exhibit segmentation, beginning to produce small embyros. A your later O. and R. Hertwig succeeded in producing the first stages of segmentation in the ovules of the *Strongylocentrotus* by the application of certain chemicals (chloroform in 1887 and strychnine, by R. Hertwig in 1896). These observations furnished a starting point for a thoroughgoing investigation as to the nature of the agents capable of producing the development of unfertilized egg-cells. It was found that artificial parthenogenesis can be produced by the most various kinds of influences—for example, by the action of the chlorides of potassium, sodium, magnesium or manganese, by carbon dioxide by ammonia, by tannin, by various fatty acids, by sperm extracts, by serums, by treatment with xylol, with toluol, ether, etc. Furthermore, the alteration of the osmotic pressure of the surrounding medium, the abstraction of water, and the most extensive variety of mechanical influences were also found to be highly effective agents in the production of artificial parthenogenesis.

The effect of some of these agents as, for example, that of the hypertonic solutions of alkaline liquids, or of the abstraction of water, etc., upon the egg is so favorable that the latter can thus be stimulated to continue its development far beyond the larval stage. As a matter of fact Delage succeeded indeed in producing young sea-urchins by purely artificial parthenogenesis.

*Translated from the *Biologisches Centralblatt* (Leipzig) of April 20, 1916.

The widest variety of opinions prevails concerning the nature and manner of the operation of all these agents upon the unfertilized egg-cell and with respect to the underlying causes of the phenomena of artificial parthenogenesis. The first experimenter along these lines, Tichomiroff, is of the opinion that the egg-cell is capable of responding to all stimuli whatever, no matter what their nature, only through a single specific reaction, namely, segmentation. Other authorities, Bataillon, Matthews, as also, and still earlier, Loeb, Delage, etc., consider the abstraction of water from the egg-cell by means of hypertonic solutions or merely through the simple allowing of the egg to dry out, as, for example, when placed upon filter paper (Giard) to be the most decisive stimulus in the production of the evolution of artificial parthenogenesis. These investigators hold with Matthews that in normal fertilization likewise, the abstraction of water from the protoplasm constitutes the original cause of the beginning of segmentation, since it is a well known fact that both the male and the female pro-nuclei increase in size during their growth by the absorption of liquid from the surrounding protoplasm.

Other explanations that have been suggested as the cause of artificial parthenogenesis include also the action of the ions of the reagents employed upon the egg-cell (Loeb), the effect of the alkalinity the alteration of the peripheral layer of the egg-cell by the alkaline and lipoid-dissolving reagents, the enzymic effect of the sperm extract, etc.

From this multitude of attempts at explanation two have recently come into especial prominence, mainly, those of Loeb and of Delage—theories which at first glance lie far apart.

Loeb takes as a starting point the following observations: experiment has proved that hypertonic solutions exert a strongly stimulating effect upon the vital processes of the egg-cell—in other words they are remarkably effective parthenogenetic agents. However, the cells produced though the segmentation of the artificially fertilized ovule would separate from each other and perish if other stimuli failed to appear. The cells produced by segmentation are held together by the formation of an egg-membrane. In the process of the artificially induced development the formation of this egg-membrane can be brought about by the brief action of reagents capable of dissolving lipoids and fats. By means of this process a portion of the superficial lipoid and fat-layer of the egg is dissolved, the space thus formed by the exudation from the plasma is taken up and in this manner the yolk-membrane which is characteristic of the fertilized *Echinidus* egg is formed. The dissolved lipoid substances are employed for the nuclein synthesis which begins to take place energetically in the process of segmentation. Basing his experiments upon these observations Loeb has succeeded in fact in producing an extremely effective compound of chemical agents—namely, fatty acids and hypertonic solutions (chloride of magnesium)—by means of whose use almost 100 per cent of the eggs treated were induced to develop, continuing this development beyond the larval stage. Delage's method of producing parthenogenetic development, which is likewise highly effective, inducing the development of practically 100 per cent of the eggs treated, is based upon very different observations. According to this authority living substance is a complex of albumens which compose a coloidal solution in an electrolytic liquid medium. This colloidal complex is in an unstable condition, so that the soluble phase and the jelly phase are each near the critical point. The segmentation of the cell is characterized by coagulation (*i. e.*, the passing over into the jellied condition, the formation of the chromolones, the appearance of the mitotic figure, etc.) or by the solution (*i. e.*, the dissolving of the nucleal membranes, etc.) of some of these albumens. In Delage's opinion, therefore, it must be possible to induce the segmentation of the cell by influencing a cell which is in a state of equilibrium with chemicals which are capable of producing the series of colloidal transformations which are characteristic of the segmentation of the cell. Delage employs ammonia as an agent of solution and tannin as an agent of coagulation. By the influence of these agents the transformations of the colloidal substance are once more set in operation and the cell consequently proceeds with its segmentation uninterruptedly.

All the theories here mentioned strive to indicate those stimuli which in the opinion of the authors are common to normal development and to that of artificial parthenogenesis. These theories take as a basic principle the concept concerning the physiological condition of the sexual cells which is today so widely accepted—namely, that in the organism the sexual cells are those which have the greatest vital capacity, but which in spite of this are subject at the end of their development to a remarkable physiological condition of equilibrium or rest. Just as the fertilization and the consequent transformations of the egg-cell forms a complex of phenomena limited to this, so likewise the effects of the above-mentioned agents of artificial parthenogenesis produce specific phenomena comparable to the normal processes of fertilization and are applicable only to the sexual cell.

Let us now enquire whether this manner of looking at the matter can be really correct, and whether it can be made to agree with our knowledge of the general physiologic nature and conditions of the cell.

As I stated at the beginning of this article—an idea which I have treated more extensively in former works—every cell in the entire organism arrives in the course of generations at a peculiar physiological state in which the vital functions greatly decline. This decline leads, little by little, to a gradual siesta or retardation of the phenomena of life, and finally, from purely internal causes, to the death of the end generation of the series of cell chains concerned. The sexual cells do not escape these functional disturbances any more than other cells. However, the sexual cells . . . possess the power to rejuvenate themselves through a fundamental reorganization and again to bcome capable of growth and division. This regulating process is brought about by means of fertilization.

According to this point of view how shall we regard the action of those agents which have shown themselves capable of producing artificial parthenogenesis? As I have already said, the mature germ cells have arrived, according to the theory here enunciated, at a condition of depression of their vital functions. By means of the action of all of the above mentioned changes the germ cells are rejuvenated. They are subjected to a process of physiologic regulation and in this manner they are again made capable of exercising their vital functions. In so far as the process of artificial parthenogenesis is a process of cell rejuvenation it is comparable to normal fertilization. Therefore, artificial parthenogenesis must also be a mere phenomenon of cell physiology falling within the dominion of rejuvenation phenomena of the cell, and, as such, being of the greatest importance in general with regard to our concepts of cell physiology.

It is true that a different cell makes its appearance in the further development of the rejuvenated germ cells and the rejuvenated somatic cells. The germ cell (of non-differentiated tissue) which is endowed with all the potentialities of an organism, must necessarily, as a final result of its segmentation occasion the formation of a new organism. Whereas the ordinary tissue cells produce during the process of division, in the course of regeneration, for example, merely a specially differentiated kind.

Starting with these theories I undertook a series of experiments to support them, which I will here describe. In order to avoid repetition I will refer the reader to earlier publications of mine (*Experimentelle Zellstudien IV, Arch. f. Zellforsch*, 1915, *D. Med. Wochenschrift*, 1915, No. 42).

I. Numerous researches concerning artificial parthenogenesis have shown that the hypertonic solutions of the chlorides of sodium, magnesium, potassium, manganese, etc., exert a very favorable regulating and stimulating action upon the germ cells. These experiments show further that the success

of such treatment depends not only upon the hypertonic nature of the solutions but also upon their chemical composition —for not all hypertonic solutions are equally effective. There is a marked superiority in the favorable stimulating effect upon the mature egg-cells in hypertonic solutions of sodium chloride (salt) and magnesium chloride. The percentage of development obtained from eggs treated with these solutions is almost one hundred.

According to the hypothesis here stated, however, such hypertonic solutions must exert a general stimulating effect upon all the cells of the body, and not a merely specific effect confined to the germ cells alone. In order to test this theory, I made the following experiments: It occurred to me that a very satisfactory object for my first test was afforded by plants in the condition of their winter rest. If it were found possible by this means to induce plant cells in a condition of rest to undergo a premature development, this would furnish a proof that the above mentioned hypertonic solutions exerted a stimulus upon cells in general. As a test plant I made use of sprigs upon an elder bush (*Syringa vulgaris*), since this plant, as I knew from earlier experiments, is more easily influenced than others.

On January 18, 1916, I took from the same branch three sprouts, whose winter buds were still closed. In one of them I injected immediately beneath the two end buds a 40 per cent hypertonic solution of magnesium chloride (about ¼ ccm.). In the second sprig I injected in the same manner and at the same place a 40 per cent solution composed of 20 per cent of sodium chloride and 20 per cent of magnesium chloride. A third sprout remained untreated and served as a control. All three sprouts were placed in the same glass which was filled with spring water and were kept at the temperature of the room, which varied from about 20° C. by day to 10° C. at night.

At the end of a week a distinct difference was observed in the behavior of the control and that of the two twigs being experimented upon. The former remained almost unaltered, while the twigs which had received the injection had swollen and their protecting scales had spread apart. On the seventh day the injections were repeated in the same manner. Each following day thereafter showed a greater difference between the control and the other twigs. The latter were entirely opened out both at almost the same time, and on the 9th day showed the tips of the flower buds. On the 14th day as shown in the accompanying illustration the experimental twigs had already reached a considerable degree of development (I and II), whereas the control (III) had increased in length but showed no open buds.

This experiment shows what a strong stimulating effect is exerted by the hypertonic injections which are employed to produce artificial parthenogenesis upon somatic cells in a state of functional repose, in this case plant cells. My experiments along this line were continued and extended.

I also made use of the experiments of Weber, Jesenke, etc., to support the results of the experiments just described. These authorities likewise caused a premature sprouting of buds by means of injections of weak solutions of various salts (salts of sodium and of magnesium).

This strikingly stimulating effect of the hypertonic solutions of the chlorides of magnesium and of sodium suggested that it would be highly desirable to test their effect upon the regeneration of wounds; if it were true, as supposed in my hypothesis that the agents employed to produce artificial parthenogenesis did not confine their action to the germ cells alone, but behaved as cell excitants in general, then their effect would be to produce a more rapid regeneration of wounds. The experiments made by me along this line gave very satisfactory results.

A—I treated both deep muscular wounds and extensive superficial ones (from 10 to 25 cm. in length and from 5 to 10 cm. in breadth) with a 30 per cent solution of hypertonic sodium chloride. The deep wounds were thoroughly washed with a solution of common salt or, when possible, the wounds were bathed in the hypertonic solution for from 20 minutes to half an hour. Wounds which were at first in an *a-tonic* condition and refused to granulate soon acquired a reddish color while the granular tissue increased in extent and the process of healing was hastened. A few examples will serve to illustrate this:

1. A large round wound of the heel 5 cm. in diameter after making some progress towards healing came to a stop. The muscular tissue was *a-tonic* and pale and refused to granulate or form epithelium. The wound remained for six weeks in this stationary condition. On January 28, a hypertonic sodium chloride solution containing also 0.5 per cent of potassium chloride and calcium chloride was applied. Shortly afterwards the wound assumed a red color and began to granulate. On February 10, it was entirely healed and covered with epithelium.

2. This patient had a fracture of the humorus from a gunshot wound; he was operated upon for the second time on January 10. There were communicating wounds upon the inner and the outer side above the elbow. The wound was treated with a hypertonic solution of sodium chloride on January 10. On January 25, the communication between the wounds was closed. The outer wound filled up but there still remained a spot about 10 cm. long and 4 cm. wide which was not covered with epithelium. The inner wound, having a diameter of 4 cm., still led into a canal about 8 cm. in depth from which there was a flow of pus. It was treated with a hypertonic bath of common salt. On February 2, this wound also healed nicely without pus. On February 14, both wounds were closed and covered with epethelium.

B—Wounds treated with a solution of 15 per cent of magnesium chloride and sodium chloride also exhibited early granulation and formation of epithelium.

1. This patient had a bullet wound in the ankle, both the tibia and the fibula being perforated. On January 26, the front wound was torn open to an area of 10 cm. long and 8 cm. wide; it was in communication with an equally large wound on the inner side of the ankle. Both wounds were suppurating. They were first washed with hydrogen peroxide and then bound with a very wet compress (a solution of magnesium, chloride, and sodium chlorides) for half an hour. On February 6, the communication was interrupted, there was no suppuration, and the wounds were rapidly granulating and had become almost superficial. On February 12, the wounds were almost closed, only a long narrow strip not covered with epithelium remaining. On February 20, the wounds were entirely healed.

2. This patient had a fracture of the left femur in November. There was a second operation on January 10. There was a deep wound 10 cm. long and 10 cm. deep on the front of the thigh; at the rear of the thigh there was a separate wound widely torn, 20 cm. long 6 cm, broad and 8 cm. deep. Both were suppurating. On the first day, January 26, after the treatment with magnesium chloride and sodium chloride, the suppuration increased and the pus was mixed with blood. On February 2, the rear wound had ceased to suppurate and was rapidly granulating. Pus still came from the front wound but was mixed with blood. From time to time the wounds were washed out with hydrogen-peroxide and then again with the solution of the chlorides of magnesium and sodium. The wounds continued to granulate and on February 8 the rear wound was in a very good condition being 4 cm. long and 3 cm. deep. On Februay 22, the rear wound was closed while a small opening leading into a canal 5 cm. deep still remained.

C—Equally favorable effects with regard to wound regeneration followed the application of the 30 per cent solution of magnesium chloride alone.

[*The author here describes three cases of serious wounds thus treated whose details it is unnecessary here to mention, though it may be remarked that in one case there were particularly remarkable results with respect to the healing of*

frozen tissues, which usually are very slow to recover.—EDITOR.]

In all these cases, as in others which will be referred to later, there was almost no medium employed of an antiseptic and tissue killing character. Only the wounds which were strongly suppurating were first washed out with hydrogen-peroxide and immediately thereafter treated with a hypertonic solution. It should be remarked, however, that in some cases the magnesium chloride alone was not so favorable, being slower in action. . . . The favorable effect of this solution is especially marked in clean wounds which can be allowed to granulate and heal.

All these experiments indicate that the hypothesis expressed above with regard to the general effect as a cell stimulus of the hypertonic agents employed to induce artificial parthenogenesis is correct.

II. This hypothesis is strongly supported by the coincidence of the phenomena exhibited in artificial parthenogenesis and those of cell stimulation observed in experiments in which plants are subjected to the influence of ether. Molisch, Johansen, Weber, et al. have found that buds in a state of repose can be induced to sprout earlier when treated for a short time with the fumes of ether . . . the effect of ether as a stimulant to development is so marked in fact, that it has been successfully used in the art of horticulture. But ether is also an agent for producing artificial parthenogenesis (Matthews, 1900), and is, therefore, to be regarded as a general cell stimulant. This naturally suggested to me to test its effects upon the regeneration of wounds . . .and experiments along this line met with surprisingly successful results. Since the use of pure ether or ether fumes upon wounds is inconvenient I employed one part of ether mixed with three parts of sterilized olive oil. This mixture of oil and ether was either applied directly to the wound or else the wound was covered with a gauze bandage thoroughly saturated with the mixture, the bandage being changed daily or every other day. The wounds treated by me in this manner were mostly cases of freezing, *i. e.* just those wounds which as a usual thing granulate very slowly and heal with difficulty.

Shortly after the beginning of the ether treatment, soon after the application of the second or third bandage, the wound was seen to turn red; shortly afterwards a healthy looking granulation tissue appeared and was soon followed by revivification of the surrounding layer of epithelium. After a short lapse of time, even after two or three weeks, very large wounds, which had previously made no progress for weeks or even months, frequently closed . . . it may be stated in fact, that the results obtained by the oil and ether treatment were the most remarkable in my whole series of experiments.

[*We have not space to describe the striking results here given in detail in the case of four wounded men.*—EDITOR.]

III. *Mechanical Stimuli.*—Tichomiroff showed that silkworm eggs can be incited to develop when mechanically irritated by brushing, stroking, shaking, etc. By agitation alone Matthews also succeeded in 1901 in inciting the development of *Asterias eggs* up to the bipinnary stage. Consequently, mechanical stimuli have also been regarded as a specific agent in the production of artificial parthenogenesis. I uphold this view. It is a matter of daily observation that callosities such as corns, the finger callouses of writers, etc., are formed at points where the cells are frequently subjected to mechanical irritation: this mechanical stimulus causes the cells to begin to divide, thus forming epithelial or dermal proliferations. In such cases the effect of mechanical irritation as a cell stimulant is obvious. And it is to this stimulation, I believe, that the favorable effect of general or partial massage must be ascribed. The said stimulation favors the vital functioning of the cells and causes their more energetic segmentation. Consequently, it is cell stimulation which is of primary importance in massage, although it has been hitherto supposed that the latter's effectiveness was mainly due to the increased circulation of the blood and consequent better nutrition of the area in question. But the best circulation is of no use if the cells fail to function properly. . . . If this view is correct then the regeneration of wounds, especially of the epithelium, will be accelerated by cautious local massage near the edge of the wound. My experiments along this line were very satisfactory, the massaged wounds exhibiting an energetic regeneration. I have found it especially favorable to rub the surface of the wounds vigorously with dry gauze. As a matter of fact, this rubbing commonly occurs unconsciously during the cleansing of superficial wounds. . . . It is a striking fact, too, that strictly immobilized arm or leg fractures are much more difficult to heal and the ends of the bones unite much more slowly than when very slight motions and friction—amost imperceptible, perhaps—are given to the area of the fracture by the feeble play of the surrounding muscle. The mechanical irritation of the osteoblasts thus produced stimulates the latter in their segmentation thus producing a more rapid formation of the bone tissue. In fact, this growth is often so hypertropic that there is an irregular thickening about the point where the ends of the bones have knit.

I III II

EFFECT OF STIMULATING ELDER TWIGS IN A STATE OF WINTER REPOSE BY MEANS OF INJECTIONS OF HYPERTONIC SOLUTIONS

I Injections of magnesium chloride. II Injections of a mixture of the chlorides of magnesium and of sodium. III Control. Places of injection are indicated at *a a*.

The same idea is supported by the phenomena of skin transference. The wound upon which the piece of skin is to be transplanted is previously rubbed for some time with a sterilized piece of gauze, which has been found to favor the transplantation. . . . To my mind it is evident that the cells underneath the transplanted piece of skin are thus stimulated so as to divide more energetically and thus produce a more rapid union between the transplanted and the original tissue.

IV.—From 1900 to 1910 Bataillon made many experiments in the effort to prove that the most effective stimulus in the production of artificial parthenogenesis is the abstraction of water from the egg plasm. . . . By the action of hypertonic solutions (of salt, grape sugar, animal serum, and the like) upon the egg water is abstracted and segmentation induced. . . . In 1910 he pierced with a very fine metal needle, eggs of the *Rana* and by this simple method produced the phenomenon of artificial parthenogenesis. He believed, likewise, that a similar operation was effected in natural fertilization, namely, the water-abstracting effect of the male and female pronuclei upon the protoplasm. . . . Whether this concept of the matter is correct or not, the important thing from our present viewpoint is that through these operations the egg-cell has its capacity for functioning restored and begins to divide into segments. In my work "Experimenal Studies IV" (1915) I have endeavored to prove that the above mentioned agents of artificial parthenogenesis are not specific, but, on the contrary, general or *universal* cell stimulants. I have endeavored

to explain the physiological meaning of the widely found phenomenon of encystment in the one-cell organisms by this method.

According to this concept encystment must be regarded as a process of cell rejuvenation, and this indeed by means of the abstraction of water from the plasma which takes place in cyst formation. . . . Similarly it has been found that the partial abstraction of water from the plasma exerts a very stimulating effect upon the regeneration of wounds.

[*The following passage, which it is here necessary to omit, gives data in support of this statement, especially with regard to the superiority of the "dry" aseptic treatment of wounds over the moist (with antiseptics) method, except where serious suppuration is present.*—EDITOR.]

It is in this manner, too—*i. e.* the stimulating effect produced by the abstraction of water from the plasma—that I believe we can explain the favorable results obtained by the dusting of wounds with various powders. For example certain clean superficial wounds were dusted over with amylum powder and bound up dry. They healed rapidly and normally. I find a counterpart to this stimulation of somatic (*i. e.* general tissue) cells in Giard's bold experiment of 1904, when he succeeded in inducing *Echinus* eggs to develop by merely drying them between two leaves of filter paper.

V—Purely out of theoretic interest I am at present conducting certain experiments with respect to the effect of sperm extract upon the regeneration of wounds. . . . Details of these will be published later.

[*In this connection the reader's attention may be called to Dr. Voronoff's experiments concerning the rejuvenation of aged animals by somewhat analogous means.*—EDITOR.]

VI.—Since we have thus proved that the agents of artificial parthenogenesis likewise exact a stimulating effect upon somatic cells we may surmise that they are also capable of exerting a favorable effect upon the general health of individuals who are sick or feeble. Such results can be obtained in fact by the sub-cutaneous or intravenous injection of solutions of sodium chloride, magnesium chloride, or the mixture of the two described above as shown in experiments on guinea pigs. . . . Such treatment has also been employed with advantage in cases of Asiatic cholera. . . .

FINAL REMARKS.

It is evident from the observations and experiments above set forth that the action of the agents capable of inducing artificial parthenogenesis is not confined to the germ-cells but is likewise exerted upon all other cells. Hence we may regard them as being cell stimulants in general. And this being true we see the immense importance of experiments in regard to parthenogenesis with respect to cell physiology in general. . . . It is equally obvious how important this subject is in energy and in medicine.

And more still! A more profound and searching investigation of the manner in which cell stimulation is effected will not fail to give us a broader comprehension of the interesting and important problem of age and of the possibility of temporarily, at least retarding the appearance of its phenomena.

We may hope to . . . to have fresh light shed in this manner upon the physiology of the processes of sex, and upon the death of the cell.

THE MOST VALUABLE CROP.

IF a man from the Dakotas or Minnesota were asked to name the most valuable crop, he would very likely name wheat; if from Illinois, corn; if from the South, cotton or sugar; but it will surprise many to learn that probably the cocoanut palm is the world's most valuable plant, producing the most important crop. Chemistry has played a large part in making this true, for it is to chemistry that we are indebted for improvements in the refining of cocoanut oil and for the use of this food stuff in butter substitutes, hydrogenated oils, and to replace animal fats in a number of instances. For example, it is a neutral, white cocoanut butter or oil which is emulsified with reconstituted, dry skim milk to produce a cream of any pre-determined fat content for use in confections, baking, and indeed wherever cows' cream is ordinarily employed.

Not only is the oil usually pressed from copra, as the dried meat of the cocoanut is called, an article of increasing commercial importance, but the cocoanut itself has recently greatly advanced in value with the demand apparently unsatisfied. This is largely due to the increase in its use in confections, the demand for candy having grown, as had been anticipated, as the result of prohibition. For example, a plant that had been established to prepare charcoal from the cocoanut shells for gas masks and produce an excellent quality of cocoanut oil from the meats, this having the advantage of being prepared from fresh material rather than from dried copra, now finds itself unable to compete with the prices paid for the nuts to be used in confections.

In acclaiming the cocoanut palm as the most valuable plant, it should be pointed out that in its native land the palm furnishes food, drink, clothing and shelter to the natives. Its fiber is woven into mats and cloth for a great variety of purposes, the tree supplies much of the timber for local needs, the nuts are almost the whole source of fats, if indeed not of food, and the milk of the nut is the usual beverage. In many islands and coasts where the palm forms the basis of all industry, the farms are tiny plots of ground, and there have been instances of litigation concerning the ownership of literally fractions of cocoanut palms situated at the intersecting lines of farm boundaries.

WEED SEEDS.

IN view of the research being conducted on the possibility of using various sorts of seeds, principally as a source of oils, it may be of interest to call attention to the article on the weed problem in the Bulletin of the Colorado Experiment Station.

We have come to consider as weeds those plants which grow where they are not desired, plants which resist men's efforts to subdue them, those which resist frost, hail, and dryness, growing in almost any kind of soil and under all conditions, those which have rapid methods for propagation, including the production of great quantities of seeds, and those which are useless or troublesome notwithstanding the fact that they are frequently beautiful. Emerson once said that "a weed is a plant whose virtues have not yet been discovered."

Weeds produce seeds in very large numbers and most of these seeds live for a long time. It has been learned that some seeds, when buried in the soil, may retain their power to germinate for fifteen to thirty years, and in this class can be named the tall pig weed, shepherd's purse, dock, and chick weed.

A large purslane plant will produce 1,250,000 seeds. A single Russian thistle produces from 100,000 to 200,000; tumbling mustard, 1,500,000; and shepherd's purse, 50,000 seeds per plant.

The seeds of many weeds are very small and consequently escape notice. A pound of clover dodder, as well as the common plantain, contains approximately 1,841,000 seeds. Lamb's quarters numbers nearly 605,000 seeds per pound and Russian thistle over 266,000; wild mustard, 216,000, and wild oats more than 25,000 seeds per pound. From this it will be seen that if sixty pounds of wheat are planted on an acre and this seed is contaminated by as little as two per cent of wild mustard seed, there will be distributed over that acre of ground more than 388,000 mustard seeds.

These new facts bring out the necessity for clean seed and the desirability of persistence in eliminating weeds from areas by destroying them before they can bear seeds. However, if the chemist find a way to use such seeds economically, it would appear that there should be no difficulty in obtaining large and constant supplies of raw material.

INSPECTING A LARGE SHIPMENT OF FOREIGN NURSERY STOCK AT THE POINT OF DELIVERY

Our Botanical Immigrants

The Quarantine Regulations of California

Photographs Copyrighted by Keystone View Co.

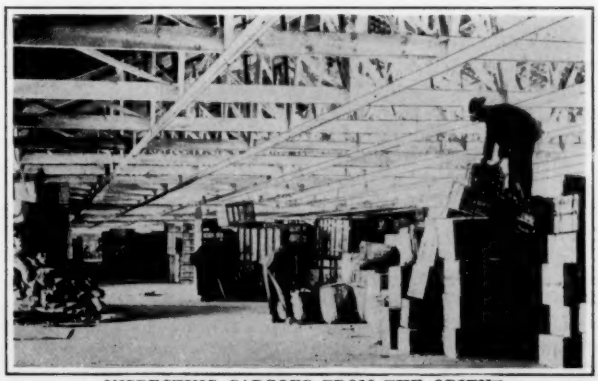
CALIFORNIA'S horticultural Quarantine service has proved a vital factor in the successful production of plant life in the Golden State, where $255,000 worth of plant products was realized during the past year. The quarantine division, which is under the control of the State Commission of Horticulture, is a public office maintained for the protection of the crops, both agricultural and horticultural produced in the State of California. Through the various ramifications of the quarantine service, it reaches and controls practically every point of delivery in the state, holding as it were a great sieve through which is strained the imports of plant products upon their arrival at every avenue of entrance and by all methods of transportation—rail or mail, land or water, freight, express or personal baggage. Under the direction of Frank Maskew, chief deputy quarantine officer, stationed at the central station in San Francisco, 240 quarantine inspectors are working. They are vested with authority to intercept, examine and pass final judgment upon the health, cleanliness and general desirability of each and all botanical products entering the five ports of entry on the Pacific Coast. They are San Francisco, Los Angeles, San Pedro, Eureka and San Diego.

At the maritime ports of entry the state is represented by ten inspectors and two clerks, and coöperating with the main division at all times by virtue of appointment of state quarantine guardians, and 227 county commissioners and inspectors stationed at the different interior points, each in constant touch with the central horticultural quarantine office in San Francisco. The state quarantine law is in force in every express office, freight depot and wharf in California.

No imported plant product is immune from inspection. They must be carefully looked over, and undergo quarantine before they land. Every vessel from the tropics and outside of Continental United States as well as those of the states of the Union are subjected to the strictest scrutiny on the part of the legal inspectors.

All botanical immigrants attempting to cross its boundaries must be found "physically" fit to live in the state. Citrus, deciduous and semi-tropical fruits as well as ornamental trees and shrubs, rice, cotton and cereals, vines, dates and melons, which are susceptible to the attack of many insect pests and plant diseases are not released until they have been found free from all the plant maladies. Every person or corporation which brings into the state plant products of any type must notify the plant officer of their arrival and hold the same for their inspection.

The attention of plant inspectors in other countries is called to the insect pests and diseases found on the ship-



INSPECTING CARGOES FROM THE ORIENT

ments of plants their countrymen are exporting with the request that a clean up be instituted at the point of origin. Under the new postal law, insect pests of orchard trees found in the parcel post are delivered to the horticultural quarantine inspectors for examination and if they are declared infested beyond treatment they are sent to the State horticultural guardian of Orange County for determination of the *Aleyrodes* infesting its foliage and for final destruction. The inspectors are ever on the alert for the white flies, which infest the cirtus trees. The Federal Government maintains a rigid control over all imports of unmanufactured cotton in the United States as a means of preventing the establishment of the pink boll worm in the cotton fields. At the port of San Francisco, the State quarantine inspectors as agents of the United States

HORTICULTURAL QUARANTINE INSPECTORS BOARDING A VESSEL

Department of Agriculture supervise and enforce disinfection of all imports arriving on the Pacific Coast from points outside of Continental United States.

The fumigation of the cotton is done in a retort. This cylinder holds 75 bales of cotton at a charge, and when filled with cotton a vacuum is created, hydrocyanic gas is admitted into the chamber and the cotton is held in the gas for an hour and twenty minutes. All imported cotton is subjected to the same treatment. Under the law, the inspectors remove and destroy all cotton and cotton lint found in the baggage and personal belongings of passengers arriving from foreign or island American ports. Cotton seed and cotton seed hulls from foreign countries are prohibited from entry under these same regulations. Every precaution is taken to thwart the introduction and establishment of the Mexican boll weevil into California and the quarantine rules covering the bringing in of cotton seed from any other state of the Union have been issued by the State Commission of Horticulture and are rigidly enforced at all times. Cotton seed from any state in which the weevil is known to exist is denied admittance and a permit must be obtained to bring it into the port for experimental propagation. The cotton seed must come from the states that are at present immune from the boll weevil. Railroad cars carrying cotton in the cotton growing states are covered by the quarantine regulations and must be cleaned of all cotton seed immediately upon arrival in California. The railroad companies comply with these rules. When necessary the cars are disinfected with live steam until all cotton in the crevices of the sides and floor is cooked to a soft condition, while in other instances such as "reefers" where the sides are ceiled smooth, the cars are swept and the cotton seed burned. An average of 200 cars, around the bay region of San Francisco, are treated by these methods, inspected, passed and recorded each month.

A vigilant watch is kept for the fruit flies in the passengers' baggage, wherein may lurk the larvae of the pestiferous Mediterranean fruit fly, which is a universal feeder on all fresh fruit and vegetables. The inspectors had a severe experience when they discovered the Mediterranean flies' larvae in seeds of the Kamani tree found in the pocket of an overcoat belonging to a passenger arriving in San Francisco from Honolulu. Had it not been for the keenness of the officer, the seed would have been planted in southern California. No domestic vessel from Hawaiian ports is permitted to land its passengers until a thorough examination is made. They are searched for contraband fruit and plant products in their personal belongings, which task is a rather delicate duty for the quarantine officials.

There are three forms of fruit flies of the Mediterranean species at work on the fruits of the Island of Sydney, one of which is the *Dacus melanotum*, which attacks the alligator

SEARCHING THE BAGGAGE OF PASSENGERS FROM THE ORIENT

pear. Fruits from Papeete on the island of Tahiti are not allowed to land on vessels excepting that which is set forth in the ship's manifest, which consists of a sworn statement of the port at which it was taken on board. The Mediterranean flies thrive in various latitudes not necessarily confined to the tropics. Fortunately it has not been established in California or in any other part of the United States.

Even the vegetable lockers on board the big liners are searched for fruits left over from the ship's supplies. Every food product that is susceptible to the fruit fly is quarantined, as are also the remnants of tropical fruits and vegetables in the ship's lockers and state-rooms.

The future of every crop produced in California depends upon the quarantine service to a large extent. A campaign is

waged against the alfalfa weevil and the white fly, which is a parasite of the fields. From Mazatlan, Mexico, come the dangerous orange maggots, which are a great menace and are known at sight by the inspectors.

Out of 58 counties in California, 42 have county horticultural commissioners or state quarantine guardians. In mountainous counties, where horticulture is not generally prevalent and where horticultural imports from outside of the state are received in a minor quantity, there is less need for the guardians. Coast ports are more susceptible to receiving fruit and melon flies.

An educational feature of the quarantine work is the entomological and pathological system by which records are kept with regard to the findings of the various pests that are discovered on the imported plant products. The clerical records and reports of the service are maintained, collated and tabulated, while the insects are charted and made instantly available for reference in connection with prospective imports of plant production. This is done so that homeward bound passengers, while enroute, may learn what plants are objectionable.

SWEET POTATOES FROM HAWAII INFECTED WITH THE WEEVIL

RESISTANCE OF GREENHEART TO VARIOUS MARINE BORERS.

To WHAT extent greenheart timber resists attack by various kinds of marine borers is being ascertained in a test conducted by the Forest Products Laboratory, Madison, Wis. Six years ago the laboratory placed specimens of this wood in the Gulf of Mexico, in waters infested with holas, xylotrya, and limnoria.

A recent examination of the timbers showed that, except for a very slight trace of limnoria on the sapwood of one specimen, they had been uninjured by either xylotrya or limnoria, although these borers are very active in this vicinity. All the timbers, however, were severely attacked by pholas. The surfaces of each specimen were covered with burrows from ¾ to ½ inch deep.

How far these burrows will extend with continued exposure remains to be seen, but it is not expected that they will extend much more than two inches. Pholas have not been found to bore very deep in wood. It is evident, however, that greenheart piles for use in pholas-infested waters should be made large enough to allow for reduction in size by pholas attack.

Elements of Combustion of Fuel Oil*

From the Report of the United States Naval Liquid Fuel Board

WHILE the theory of combustion is well understood by all having a knowledge of the elementary principles of chemistry, there are particular considerations that enter into the matter of burning both oil and coal as a fuel, and therefore the economical consumption of fuel in large quantities can be effected only in boiler or furnace installations which have been designed by technically trained experts possessing a knowledge of what well may be termed the practical mechanics of combustion.

Hundreds of oil burners have been designed, which, viewed from a mechanical or theoretical standpoint, should have operated efficiently; and yet when such appliances were subjected to actual test the devices proved unsatisfactory. There are, therefore, practical conditions as well as chemical principles that must be considered in the solution of the liquid-fuel problem, and the Board thus regards the mechanical feature of the oil-fuel combustion question as a subject deserving special study and investigation.

Everyone is aware that with a charcoal or coke fire it is possible to maintain intense combustion within a comparatively small space, and with little smoke. This sort of fire was known to the smelters of the Bronze Age, and it is still used in blast furnaces and other operations where great concentration is required.

The explanation lies in the fact that the fuel is solid, even at the highest temperature. The solid particles in the smoke are probably particles of ash, but whether they are ash or unconsumed carbon, they are exceedingly small, as shown by the bright-blue color of the smoke. As a result of this solidity no carbon can leave the bed of hot coals except as a constituent of CO or CO_2. In either case the combustion will be free of soot or smoke, since both gases are colorless and transparent. If the carbon goes up the stack as a constituent of CO, it carries with it two-thirds of the heat that it is primarily capable of yielding up, and it is only with respect to the possible formation of CO instead of CO_2 that a charcoal fire fails to give perfect results. Were it not for this possibility there would be no reason why a charcoal fire should need more space than is sufficient to contain the fuel itself.

The obvious way to prevent the formation of CO, is to force a larger quantity of air through the bed of coal, but this alone is insufficient. Experience shows that even when the amount of oxygen passing through the bed of coal is twice that requisite for the complete combustion of carbon, there is still some of the carbon that leaves the furnace in a partly burned condition. The only way in which this carbon can be completely burned is by subsequent diffusion of the gases, whereby each molecule of CO sooner or later meets with an atom of free oxygen and so becomes CO_2. But this diffusion requires time, and as the gases are being constantly cooled as they are carried along it may happen that they will be cooled below the ignition temperature before union takes place So that even in a charcoal fire the need for appreciable combustion space is obvious.

THOROUGH MIXTURE ESSENTIAL TO GOOD COMBUSTION.

Complete combustion requires that for every atom of carbon, and for every two atoms of hydrogen, there shall be at least one atom of oxygen brought in close proximity, and then and there subjected to a temperature sufficient for ignition. In other words, there must be a thorough mixture, and then

*Reprinted from *Power*, March 2, 1920.

ignition. It is doubtful if a mere mechanical mixture, however complete, could ever be perfect enough to bring about the desired result. This is well illustrated by contrasting the smoky combustion of black gunpowder, where there is a mechanical mixture, with the combustion of the so-called smokeless powders in which the mixture is so thorough and minute that similar proportions of oxygen, carbon and hydrogen occur in each separate molecule.

In all ordinary cases of combustion, however, where we draw our supply of oxygen from the atmosphere, it is only by virtue of the property of diffusion that a sufficiently intimate mixture is attained. As to the real nature of diffusion, it is known that at ordinary temperatures the particles of oxygen in the air are moving in every conceivable direction with velocities averaging over 1600 feet per second. Any one atom, however, moves only an inappreciable distance before being arrested by collision with another atom, so that although the average velocity of the atoms is probably equal to that of a rifle ball, it still takes an appreciable time for a particle to travel even a moderate distance. It is this time element that constitutes the great stumbling block when the attempt is made to burn a large amount of combustible in a small space.

COMBUSTION OF HYDRO-CARBONS.

As before noted, the reason why intense combustion is easily attained with a charcoal fire is that the fuel is solid at the temperature of ignition. Being solid it can present a large surface for the oxygen to act upon, and an atom cannot break away and go up the chimney first without being united with at least one atom of oxygen. In the combustion of hydro-carbons, on the other hand, we have the following condition: The fuel is already on its way to the chimney before it is even partly burned. The first effect of the heat is to dissociate the carbon from the hydrogen. Whether or not the latter unites with the oxygen does not affect the soot or smoke question, since the constituents, and also the products of combustion of hydrogen, are like transparent colorless gases. But in any case the carbon left alone in the form of an impalpable dust is much less favorably circumstanced than that in a charcoal fire. If it were attached to a hot coal, as in the charcoal fire, so as to be capable of receiving a blast of air, its combustion would be easily accomplished. But instead of this it is carried along by the current of gases, and unless it is given plenty of time before being cooled it will be left alone as a particle of soot.

An examination of the nature of flaming leads to similar conclusions. The luminous part of a flame is caused by the white-hot particles of carbon. These particles have been robbed of the hydrogen with which they were formerly associated, and they have not yet met the oxygen necessary for complete combustion. This process of finding, or of being found by, the oxygen requires time, and if perchance the temperature falls below that of ignition before the process is completed, the carbon will be deposited as soot or else go on up the stack as smoke along with the excess oxygen, with which it should have been united. Thus an unmistakable symbol of the conditions that are necessary to burn a large amount of combustible in a small space is a short flame. The circumstances which conduce to shortness of flame are: First, pure carbon fuel, because the fuel cannot leave the grate or furnace until it is burned to CO at least. In any case it cannot deposit soot, since CO, when cooled, is a transparent gas. Second, intimate initial mixture of oxyyen with the fuel, since the more intimate the mechanical mixture the less time will it take the gases, by the process of diffusion, to become perfectly mixed. Third, initial heating of the air, since the rate of diffusion increases with temperature. Fourth, large surface of fuel presented for impact of the oxygen.

PROPER SIZE OF COMBUSTION SPACE.

The desirability of supplying a combustion chamber whose volume is at least equal to the volume of the flame seems obvious. In this connection the fact should not be overlooked that a slight increase in the volume of the combustion space acts two ways to improve the solidity of combustion. One way —that having to do with the greater time permitted for diffusion—has already been touched upon; but apart from that there are influences that work, in consequence of which an increase in the volume of the combustion space actually diminishes the volume of the flame. This is because the temperature of the larger space is higher, and the higher temperature hastens the process of diffusion.

During the process of diffusion heat is being liberated at all points throughout the combustion space. Therefore, all parts of the space are being traversed by heat rays emanating from every other part of the combustion chamber. It is readily seen that the temperature within the space must under these conditions increase with the volume to an extent limited only by the transparency to radiant heat, and by the temperature of dissociation at which necessarily heat ceases to be liberated. Since the transparency of the combustion space is diminished by the presence of solid carbon (for whether black or incandescent, it is in any case opaque), it follows that the increase of temperature with a given increase of volume will be less in a space filled with luminous flame than in one filled with burning hydrogen or CO.

INCANDESCENT WALLS HASTEN DIFFUSION.

The question of the proper size of the combustion space is further complicated by the presence and condition of the solid walls of the furnace; whether, for instance, they are themselves incandescent, or merely black absorbers of heat. There seems no reasonable doubt, however, that incandescent walls will hasten diffusion and hence shorten flame.

Where it is possible for the diffusion to be completed before combustion begins as in the bunsen gas burner, the difficulties naturally disappear, and there is readily attained a very short flame, which, moreover, is incapable of depositing soot, even on a cold body.

In the case of liquid fuel, which is incapable of vaporization, the diffusion and ignition must occur simultaneously. With such a fuel there is bound to be considerable flaming. Another difficulty, and one from which all solid fuels are free, arises from this sort of fuel from the action of capillary or surface tension. Thus no matter how finely the liquid is pulverized, each tiny drop assumes a spherical shape and presents the least possible surface for impact of oxygen atoms.

From what has been said it is clear that a liquid fuel, such as crude petroleum, requires an ample combustion space—more, indeed, than does almost any other sort of combustible material.

The relative dimensions, like breadth and depth, of the combustion space are of minor importance. A primary requisite is volume, and that alone provided all parts of it are traversed by the same quantity of gas in a given time—in other words, provided the gases are not short-circuited through or across some parts of the space to the neglect of others. The advantages are in favor of the combustion space of large cross-section and short in the direction of the flow of the gases.

A primary requisite for the successful burning of a non-volatile liquid fuel is the exposure of the fuel to the heat of the furnace in such a form that it presents the largest possible surface for the impact of the atoms of oxygen. From the principles of capillary action it is possible to establish a standard by which to judge of the efficiency of the various methods of increasing the free surfaces of the oil.

Oil in bulk has practically no surface. When broken up into fine drops, the surface is the aggregate surface of all of the drops. The smaller the drops the more perfect the spheres. Hence, drops of oil one-thousandth of an inch in diameter are known to assume the spherical form with a rigidity comparable to that of a steel ball one inch in diameter. The work necessarily performed by the atomizing agent is simply the work of stretching the surface.

FIG. 1. PUFFER FISH DISTENDED WITH WATER

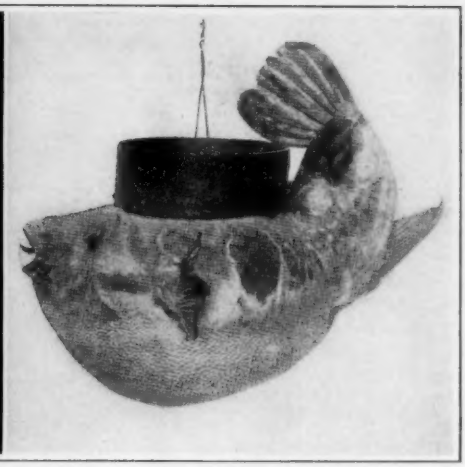


FIG. 2. A DRIED PUFFER LANTERN

Puffer Fishes*

Some Interesting Uses of Their Skins

By E. W. Gudger, American Museum of Natural History

THE puffers are fishes inhabiting tropical and warm temperate seas, and sometimes drifting beyond these limits in warm currents. The Gulf Stream, for instance, carries them as far north as Woods Hole, Massachusetts, while along the North Carolina coast they are very abundant; the writer not infrequently taking a dozen at one haul of the seine in the harbor of Beaufort.

The puffers are short-bodied fishes devoid of scale, or rather having these transformed into spines strong or weak, and are especially notable for having the skin over the belly loose and very distensible. The fish by inflating the abdomen with air or water may more than double its volume, and become a veritable balloon, whence the names puffer, globe-fish, balloon fish. When thus inflated the fish becomes more or less globular in shape with the fins and tail forming mere protrusions. If filled with air, the fishes float at the surface belly up like so many small balloons, for poor swimmers at the best, they are now entirely at the mercy of the wind and tide, having practically no power of locomotion whatever. I have taken scores, almost hundreds of puffers at Beaufort in the seine, and in the great majority of cases they came ashore more or less inflated. If filled with air the fisher boys are sometimes cruel enough to jump on them to hear them explode.

The puffers may readily be caused to inflate their abdomens by fear, by driving them against some obstacle like the net, and especially by scratching them on the belly. I have often taken advantage of this latter characteristic to cause them to swell up, in order to display them to visitors in the aquarium of the United States Bureau of Fisheries laboratory at Beaufort, North Carolina. The air or water is taken into the stomach or into a sac lying in the body cavity external to the stomach, the opening into this being in the throat. This opening has a valve-like structure which readily admits air or water but refuses exit unless at the will of the fish. Air or water is swallowed in a gulping fashion, the abdomen becoming more and more tense like a football bladder attached to a pump or being blown up by a strong-lunged boy. When the water is allowed to escape it comes in intermittent spurts at first, later in a stream, and finally this declines to a mere trickle.

In this connection reference may be made to an interesting modification of this habit in the common swell-toad of our southern coast, *Chilomycterus spinosus*. Dr. Townsend,[1] Director of the New York Aquarium, has noted that this fish in the exhibition tanks there, will sometimes come to the surface and sticking out its mouth will squirt a small stream of

*Reprinted from the *N. Y. Zoölogical Society Bulletin* (New York).

[1]Townsend, C. H. Water-throwing Habit of Fishes in the New York Aquarium, *Bull. N. Y. Zoöl. Soc.*, April, 1909, p. 488.

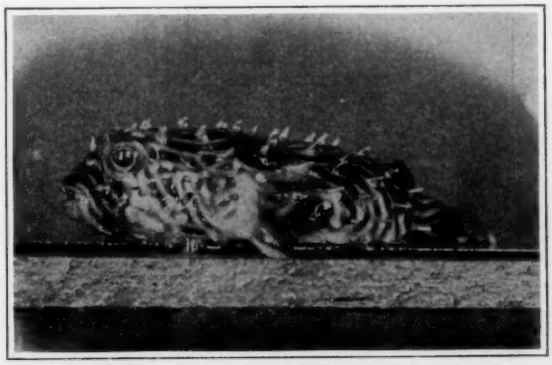


FIG. 3. BUR-FISH, CHILOMYCTERUS SPINOSUS

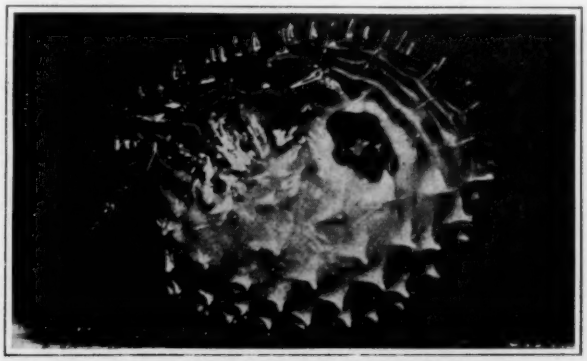


FIG. 4. BUR-FISH FULLY DISTENDED

water into the air. This habit, however, was noted for *Diodon* by Arthur Adams so long ago as 1848.[2]

The trick of inflation is a great means of protection to the puffers. An enemy fish would certainly be greatly astonished and even disconcerted to have a puffer in a few moments swell up to twice its size. Moreover, the rotund shape of the distended fish is a protection against its enemies, since only a fish of extraordinary gape can take one in whole; the ordinary fish in biting at a puffer merely pushes it away or causes it to roll over. Further these fishes, especially the ones called porcupine fishes, are covered with spines, *Diodon hystrix*, with its long, slender, needle-pointed spines, being the best example. If the puffers with few and weak spines are well protected by their ability to inflate themselves how much more are those like *Diodon*, which when inflated are covered hedge-hog-like with an almost impenetrable forest of fine pointed spines.

Some of the puffers grow to be three feet long, but these are the giants of the tribe. The largest ever seen by the writer was about two feet long, and the smallest about the size of a forty-four-caliber bullet, or the size of the end of one's little finger. This was a little *Chilomycterus antillarum*, as its name indicates, a straggler from the far south, taken by the writer in a tide-pool, on a sandbar in the mouth of Beaufort

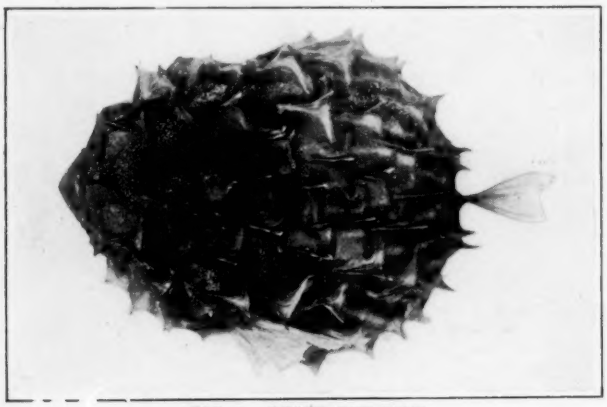


FIG. 5. DRIED BUR-FISH
Photographed from above by the author

Harbor. It was an interesting little fiesh, and, as it was kept in an aquarium for some time, it became a pet. It fed greedily on bits of oyster and I used, when it was trying to swallow a fragment of oyster, to take it in my hand and tickle it on the belly whereupon it would partly inflate its abdomen. Then when freed in the aquarium it would set its tiny fins and sculling with its diminutive tail would make its way to the bottom. However, its small specific gravity would not let it remain there, and like a true balloon it would come to the surface only to begin the struggle again, and this would continue until the oyster was swallowed so that the air could be discharged.

The puffers belong to that suborder of fishes known as Gymnodontes, naked-toothed fishes, so called because the lips are drawn away from the teeth whihch in turn are solidly fused into beak-like masses. The puffers considered in this paper belong to two of the four families which comprise the *Gymnodontes*. The first family is that of the puffers proper, the Tetraodontidæ, so called because each beak is divided by a suture in the median line into two halves, making four parts to the jaws; *tetra*, four; *dens*, tooth: four-toothed. These fish have an inflatable sac lying outside the peritoneum with an opening in the esophagus. The other family is that of the porcupine or globe-fishes, the Diodontidæ, which have

[2]Adams, Arthur. Notes on the Natural History of the Islands (of the East Indies) in Sir Edward Belcher, Narrative of the Voyage of H. M. S. Samarang in the years, 1843-46, Employed in Surveying the Islands of the Eastern Archipelago. Vol. II, 1848.

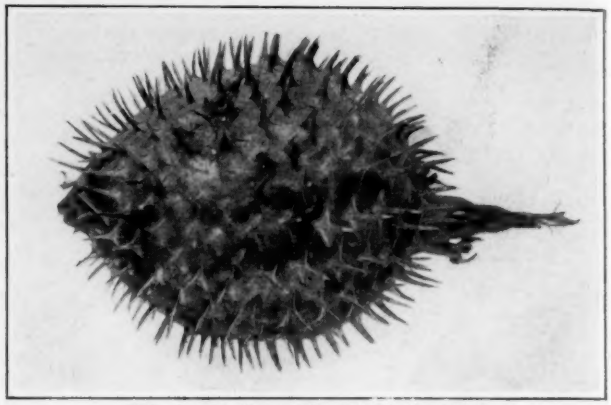


FIG. 6. GLOBE FISH, LATERAL VIEW
Photographed by the author

no suture or fissure, and hence are Diodontids (*di*, two; *dens*, tooth) two-toothed. These inflate the abdomen by taking air or water into the stomach, its exit being controlled by sphincter muscles in the gullet.

The common puffer, swell-fish, or swell-toad of our Atlantic Coast is the Tetraodont *Spheroides maculatus* whose name describes its appearance quite accurately. It is taken so frequently in the seine at Beaufort that it is not even regarded as a curiosity. Fig. 1 is a side view of this fish showing how it distends itself with water.

Another Tetraodont puffer found on the North Carolina coast, is the so-called rabbit-fish, *Lagocephalus laevigatus*. While not common at Beaufort, the fish is occasionally taken in haul-seines, and in the course of ten summers' work at the Bureau of Fisheries laboratory there the writer has seen some half dozen specimens. The fish justifies its name—*laevigatus*, smoothed; *Lagocephalus*, hare-head—inasmuch as the head and mouth somewhat resemble those of a rabbit, and the skin is smooth and entirely devoid of prickles.

The porcupine-fishes and the bur-fishes belong to the second family referred to above, the Diodontidæ, and are fishes having all the tooth structures in each jaw confluent into a turtle-like beak. In addition to their peculiar tooth structures these fish have the scales converted into spines or prickles. Two genera of this family are found on our Atlantic coast, *Diodon* and *Chilomycterus*, and both are reported from Beaufort, the former from one specimen only and the latter from hundreds.

Chilomycterus spinosus, the spiny toad-fish, is the most common puffer on the North Carolina coast. Caught by dozens in the seine, our aquarium in the Beaufort laboratory

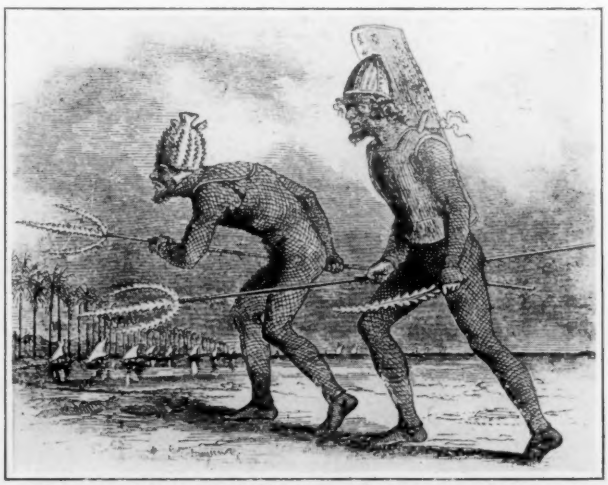


FIG. 7. DIODON SKIN HELMET—DRUMMOND ISLANDER (KINGSMILLS). AFTER WILKES

FIG. 8. A TARI TARI ISLANDER, GILBERT GROUP, WEARING A DIODON SKIN HELMET. AFTER MAYOR

FIG. 9. MARSHALL ISLAND NATIVE WEARING A DIODON SKIN HELMET. AFTER ALEXANDER

FIG. 10. GILBERT ISLAND WARRIOR WEARING A DIODON SKIN HELMET. AFTER HARTZER

was rarely without one or more specimens. However, it was necessary to watch it in one of the large tanks in the New York Aquarium to see a feat next in interest to its habit of inflation. Here one day Dr. Townsend pointed out its habit of getting in the current of the incoming jet of water and turning somersaults. Fig. 3 shows the specimen *au naturel* while Fig. 4 is from a photograph of an inflated specimen.

Both these figures[3] are from photographs of a living fish, while Fig. 5 is a dorsal view of a dried specimen in the author's possession. The spines on this puffer, as all the figures show, are short and blunt and not very offensive.

The most interesting of all the puffer-fishes is the porcupine or globe fish, *Diodon hystrix* (*hystrix*, the porcupine or hedgehog). This fish is a tropical form, common to all the warm oceans of the world, but on our coast is not normally found north of Florida. As a straggler the Gulf Stream sometimes carries it as far north as Woods Hole, Massachusetts. At Beaufort but one specimen has ever been taken, and that curiously enough was a young specimen only two and five-tenths inches long. The fish is not uncommon in southern Florida, and in the curio shops at Key West there may be seen elegant specimens of the fully distended dried fish, some fifteen inches in length. During several summers spent at the Tortugas laboratory of the Carnegie Institution of Washington, I was constantly on the lookout for the porcupine-fish, but vainly so. However, Prof. W. H. Longley one day had the good fortune to see two fine specimens drift by the eastern dock, but tantalizingly just out of reach of his longest dip net. They were fully inflated and were rapidly carried out to sea by the tidal current setting in that direction. As all the boats were on the other side of the island, half a mile away, pursuit was out of the question. Fig. 6 is a lateral view of a dried specimen in full inflation.[4] This figure shows well the justification of the names, porcupine-fish and globe-fish.

These fish, when put alive into preserving fluids like formalin or alcohol, will sometimes die inflated, and may then be dried. I have found it better to dilate the stomach or extraperitoneal sac with strong formalin pumped in with a syringe, and then to hang the fish up until it is both dry and cured. Such fish are quite translucent and Dr. Townsend has in the New York Aquarium such a fish, an Hawaiian species, converted into a lantern, the fish being hung up with a candle or small electric light suspended inside. Fig. 2 is reproduced from a photograph of this puffer-fish lantern and is taken from Dr. Townsend's article on "The Puffer, Its Defense by Inflation," published in the *Bulletin* of the New York Zöological Society for March, 1916, page 1331.

In this article Dr. Townsend further says:

"It is a common practice with the Japanese to make lanterns of inflated and dried puffers by cutting out the back as shown in the accompanying photograph of a puffer 'lantern' in the New York Aquarium. A candle suspended by a wire serves as a light which shows as brightly through the stretched skin of the fish as through a piece of oiled paper." The puffer from which this lantern is made is eighteen inches long. In the course of a fairly extensive examination of books of travel in the South Seas, a number of instances of a still more remarkable use of the skin of the porcupine fish *Diodon* has come to hand. If this fish makes use of its spine-covered skin for its own protection, why should not man likewise and for the same reason use it? And so the ingenious natives of these interesting regions have done. Commander Charles Wilkes, in Vol. V of his Narrative of the United States Exploring Expedition during the years 1838-1842 published in 1845, has on page forty-eight a figure of a Drummond Islander wearing a helmet made of the dried skin of a porcupine fish, *Diodon*. There is, however, no reference to it in the text. The figure is reproduced herein as Fig. 7. Wilkes also gives a separate drawing of the helmet.

A few years later (1847), however, we come across a very definite statement in John Coulter's Adventures on the West Coast of South America and . . . Including a Narrative of Incidents at the Kingsmill Islands, etc. In Vol. I, page 191, he describes the Drummond Islanders (in the Kingsmills) accoutered for war, the head being "surmounted by an extraordinary looking apology for a helmet, in a conical shape and made of dried fishes' skin, with two or three feathers of various colors stuck in the top for a plume." In the next few pages he twice refers again to this "fish-skin cap."

Likewise George French Angus, in his book Polynesia (London, 1866), says of the Kingsmill warriors that: "On

[3]These photographs were made in the Fisheries Laboratory at Beaufort by a professional photographer whose name cannot be recalled.

[4]This dried specimen was very kindly loaned me for photographic purposes by Mr. E. E. Hanner of Greensboro, N. C.

the head is worn a cap formed of the skin of the porcupine fish, bristling with sharp spines."

The next account chanced upon is from the pen of William Wyatt Gill, a missionary in the South Seas whose powers of observation were keen and highly developed as the wealth of natural history notes in his books shows. On page 108 of his Jottings from the Pacific (New York, 1885), he writes that "The Islanders came to see the white strangers and to dispose of helmets of porcupine fish (skin)."

Chronologically we next come in 1890 to James Edge-Partington and Charles Heape who published at Manchester, England, in two volumes their very interesting Album of the Weapons, Tools, Ornaments, and Articles of Dress of the Natives of the Pacific Islands. In Vol. II, page 170, is a figure of a native of the Kingsmill Group wearing a cap of fish skin. There is no descriptive text and as the figure is not very distinct, it will not be reproduced here.

Our next authority is James M. Alexander, whose book The Islands of the Pacific was published in 1895. To face page 222 is a plate, the lower half of which, shows a Micronesian wearing a dried *Diodon* helmet. Comparison with Wilke's figure shows that Alexander has copied it without giving any credit whatever. To face page 230 is another plate the lower half of which is labelled "Marshall Island Warrior." This man also wears a *Diodon* helmet. This figure is given as number 9 of the present paper.

Our next reference is to a book[5] by Ferdinand Hartzer, a Catholic missionary in the South Seas. Under date of 1900, he writes that the Gilbert Islanders go into battle variously armed while "A casque, fashioned out of the dried skin of a large fish with strong spiny scales surmounts the head as a helmet." On this same page is a pen and ink sketch showing this helmet and to face page 248 is a photograph of a native in full armor. This latter figure is reproduced herein as Fig. 10.

Few men of the present day have a wider or more accurate acquaintance with the South Seas and with the customs of the people living therein than Dr. Alfred G. Mayor. In an article, "Men of the Mid-Pacific," in the *Scientific Monthly* for January, 1916, Dr. Mayor has an illustration showing a warrior of Tari Tari Island, Gilbert Islands, armed with weapons beset on the edges with sharks' teeth, and having on his head a helmet of dried *Diodon* skin. Through Dr. Mayor's kindness, this illustration is reproduced as Fig. 8.

Study of the localities noted above shows that the use of dried *Diodon* skins for helmets is confined to the inhabitants of the Kingsmill, Gilbert and Marshall groups; in short to that part of Oceanica known as Micronesia, the region of "little lands," as these islands have been named. The reason for this must be an ethnological one, and in that science the explanation must be found.

[5]Hartzer, Fernand. Les Iles Blanches (Archipels Gilbert et Ellice) das Mers du Sud. Paris, 1900.

Milk and Petroleum*

Loss of Efficiency in Lubricants Due to Refining

By Edward G. Acheson, Sc. D.

THERE is a striking similarity in the physical make-up and composition of milk and petroleum and this likeness is carried throughout the natural and artificial treatments they are subjected to.

In milk the major part is just plain simple water in which are millions of minute particles floating about. These small particles are invisible to the naked eye, nor can they be seen in the ordinary powerful microscope. It is only by the use of an ultra-microscope that they can be detected, and then they are seen to be in constant vibration even after the milk has been standing at perfect rest for a long time.

The manner in which the ultra-microscope makes it possible to see the minute particles in the milk can be well illustrated by means of a very common and well-known fact. You look across a room or at an object in the room and see with such distinctness that you comment on the perfect clearness of the air. Now darken the room and allow a ray of sunlight to pass through the air and you at once trace the line of the sun's rays by innumerable particles of solid matter floating in what you formerly thought was perfectly transparent air. They have been made visible by the sun's rays when thrown into contrast with the surrounding darkness. So with the ultra-microscope. By means of a ray of arc light minute particles that are invisible under a powerful microscope, are made visible in the same instrument by means of this bright illumination. These minute particles in vibration are termed in scientific language colloids and the vibratory movement was first seen by a man of the name of Brown, and ever since this movement has been known as the Brownian movement.

The fresh milk as taken from the cow is largely or wholly composed of three substances. The greater part is pure, ordinary water. In this water are colloids of two distinct varieties. If a pan of fresh milk be set aside it is only a matter of a few hours until the colloids of one variety collect at the top of the milk where they form our well-known cream. The cream having been skimmed from the milk and set aside will in a short time sour, an acid having been formed in it. This sourness or acidity causes the colloids of the cream to coagulate, or gather together in small globules, which are recognized as fat. The soured cream is next put through a churning process which causes the small globules of fat to unite, forming what we know to be butter, and this when carried to the proper state is removed from the water.

Having disposed of our cream by the removal of the colloids as butter, we will now turn to what we ordinarily term our skim milk, and we find in due time this will also turn sour and the white matter in the milk coagulate, and perhaps you have seen this product poured into a suitably arranged bag and the water drained out, leaving our cottage cheese in the bag. With the removal of the colloids in the form of cottage cheese and the final elimination of the water we have completed the total destruction of the milk and its separation into three products, butter, cheese and water, and the first step in this separation is the formation by Nature of an acid within the liquid, the presence of this acid being quite essential for the removal of the fats, or food material, from the water with which they are associated. An alkali, such as lime or caustic soda, would have accomplished the same result, but Nature uses an acid as the means.

Petroleum as taken from the earth is also full of colloids, but it is not so easy to understand as milk. Its chemical composition is now well known, but there has not been a clear comprehension of its physical make-up, and this notwithstanding the fact that the value of petroleum largely depends on the physical characteristics of its several components which range from the thin, clear benzine, through our kerosene, fuel and lubricating oils. The thickness, or what is termed viscosity, of these several component parts increases in the same order from the benzine to the heavy lubricating oils.

*Reprinted from *Oil News*, Jan. 20, 1920.

An examination of the many products of petroleum, by means of the ultra-microscope, discloses the fact that colloids exist in all of them with the exception of the benzine, and, further that the number of colloids present increases as the petroleum product increases in viscosity, and this, naturally, leads to the idea that the viscosity may be due to the presence of the colloids, but whether that be true is not an assured fact, yet it is a fact that it is to them that lubricating oils owe their greasiness and unctuousness. It is the greasiness of lubricating oils that causes it to adhere to the surfaces of the shaft and bearings, thereby keeping them separated, while its unctuousness causes easy slipping of the surfaces, and as these two qualities are due to the presence of the colloids, it is evident the real value of the lubricating oil lies in these colloids.

As the value of petroleum lubricating oil lies in the colloids present in the oil, and, in turn, the existence of our industrial life depends on lubricating oils, it is well to have a fair understanding of the nature of these all-important ultra-microscopic particles. They have the greasiness and unctuousness of the butter colloids, which are commonly known as fat, hence we cannot be much in error if we call the colloids found in petroleum, fat. One we know as an animal fat, and the other we will call petroleum fat.

It is quite well understood that an animal fat cannot be rubbed off a surface upon which it has been applied, nor will plain water remove it. We use soap and water. Apply such a test as this to a lubricating oil. Take the same oil before and after being subjected to the usual filtering process as carried out by the oil refiners: select four pieces of glass, such for instance, as the common glass slide used in mounting objects for microscopic examination; on the center of one slide place a drop of the unfiltered oil and cover the drop with another one of the slides; on the third slide place a drop of the filtered oil and on this place the fourth slide. Now taking these two sets in your hands between the thumbs and fingers, rub them for some minutes, after which place both hands beneath the surface of water and continue rubbing the two sets of slides under the water the same as they were rubbed in the air. In a few minutes it will be found that the two glass plates between which the filtered oil was placed are in contact, the oil having been washed away by the water, whereas the plates between which the unfiltered oil was placed are not in contact, and upon removing the slides from the water it will be found there is a real grease or fat body between the glass plates, and this cannot be removed, excepting by the use of soap and water. The result of this test can only be construed as proof that the filtering removes valuable fats, the oil being improved in appearance at the expense of its efficiency.

All colloids are subject to much the same laws. Acids, most alkalies and chemicals generally are poison to them, their colloidal state being destroyed, as has been shown in the case of the soured cream and skim milk. Another important point is that they adhere to any object they are brought in contact with. This fact has been commented on as a valuable one in lubrication when they adhere to the surfaces of the shaft and bearing.

Having thus briefly, and in a very general manner, reviewed the characteristics of colloids, and more particularly fat colloids, let us look into the methods usually practiced in the so-called refining of petroleum lubricating oil.

Previous to the discovery of petroleum in quantity, there was sold on the market for illuminating purposes, what was called "coal oil." This coal oil in its use was made to ascend a wick, and to do so successfully it was found necessary to treat it with sulphuric acid in order to free it from impurities that caused clogging of the wick. This same acid treatment was found necessary with kerosene as taken from petroleum. The preparation of kerosene for the market eventually took some such form as this—treatment with strong sulphuric acid followed by a treatment with caustic soda, followed by washing with water, followed by filtration through fullers' earth. It would not be expected that any fat colloids present in the crude kerosene would escape this extended chemical and filtration treatment. Nevertheless, some of them do, as can be seen in an ultra-miscroscope. It is the presence of these few fat colloids in kerosene that causes this liquid to produce a grease spot or stain on any fabric it is brought in contact with. The main purpose of the chemical and filtration treatment of kerosene is to remove the fat colloids.

It may be found difficult to believe that this highly successful method of removing the fat from kerosene would be used in the treatment of lubricating oils, for their worth is wholly due to them, but nevertheless, such is the fact. A number of methods and processes are practised in the treatment of lubricating oils, but each of them contains all or a part of the steps practised with kerosene. In some cases as must as eight per cent in volume of the oil is lost in the treatment with a sulphuric acid and still other amounts are lost in the caustic soda and filtration treatments. At least one-half of the coal consumed in making steam to run manufacturing plants is wholly lost in friction, and as our lubricating oils are used to reduce or prevent friction, any treatment that tends to diminish the lubricating value of the oil should be looked upon with pronounced disfavor.

Undoubtedly the processes through which the oils are passed improve their appearance immensely because the presence of the fat colloids tends to produce a dark and rather unpleasing apparance, and this is quite objectionable from a salesman's point of view. The public, and more particularly the manufacturers, should not be interested in the color of an oil. They should demand of the oil salesman some proof as to the lubricating values of the oils he offers for sale. Evidently the refiners must know their refining processes reduce the efficiency of the oils as lubricants as evidenced by the fact that they use black oil that has not been subjected to a high degree of refining when they themselves undertake extensive lubrication, as in railroad car journals.

The more thoroughly the question of lubrication is studied, the more positive the conviction becomes of the truth of the statement recently made by Mr. W. B. Hardy, F. R. S., secretary of the Royal Society of England, that "the problem of lubrication is merely a special problem of colloidal physics."

CONTRAST SENSIBILITY OF THE EYE.

A KNOWLEDGE of the contrast sensibility of the eye is very essential to the proper understanding of the theory and use of searchlamps and searchlight illumination.

The searchlamp is used at night when the eye is generally adapted to low levels of illumination. If the observer is far removed from the searchlamp the illumination may be simply that from the moon and sky. If he is near the lamp, however, he must look through the diffused light along the beam.

In order to be visible, the target must be illuminated to a degree that will make sufficient contrast in brightness or color between it and this surrounding field. Data are given showing the relationship that exists between the brightness and the size of the target and the brightness of the surrounding field.

In these experiments a large surface painted white was illuminated with an incandescent lamp. The target consisted of a rectangular spot of this surface more brightly illuminated by means of a projection lantern, equipped with a simple bilateral slit. The image of the slit determined the boundaries of the test spot or "target," the length of which could be varied by varying the slit width. Precautions were taken to have the brightness across the image of the slit uniform. The brightness of either the test spot or field could be varied by means of sectored disks, so that any desired contrast between them could be obtained for any given brightness of field.—Abstract of *Scientific Paper of the Bureau of Standards* No. 366, by Enoch Karrer and E. P. T. Tyndall.

The Synthetic Tannins and Their Use in Tanning*

Efforts to Replace the Natural Vegetable Product

By Ed. Nihoul, D. Sc., Professor of Chemistry at the University of Liège

ACCORDING to Trimble's classification, the one most generally accepted, the tannins are divided into two groups: the pyrogallic tannins and the catechic tannins.

Pyrogallic Tannins.—These tannins are derived from pyrogallol, and possibly, in the case of some of them, from phloroglucine. This group includes the tannins extracted from the wood of the oak and the chestnut and from the bark of the willow as well as the tannins obtained from the sumac, the valonia, the divi-divi, the algarobilla, and the myrobolans.

All of these tannins behave differently with respect to hides and yield dissimilar results. This is due in large part to other substances combined or associated with the gallotannic acid. Among the former those of special importance are gallic acid, ellagitannic acid, ellagic acid, and other compounds whose molecular formulas are not known and among which several (catellagic, metallagic, and flavellamic acids) differ from ellagic acid only in their oxygen.

The tannin of oakwood is supposed to be a methylic derivative of gallotanic acid mixed with other compounds which readily insolubilize the surface of fibres. The myrobolans, the valonia, the divi-divi, and the algarobilla even contain besides gallatanic acid another compound, ellagitannic acid, which yields a deposit of ellagic acid either through the action of ferments or of mineral acids.

The extracts of oak wood, divi-divi, and algorabilla contain pyrogallic tannins which resemble at once gallotanic acid and ellagitannic acid. Gallic acid is found in the company of most of the pyrogallic tannin, from which it is derived by hydrolysis. Gallic and gallotannic acids are quite well known, while our knowledge of the other two is of more recent date. Ellagic acid is particularly interesting because of its importance in the tanning of heavy leathers. Perkin has demonstrated that it is a double lactone derived from hexa-hydroxy-diphenyl-dicarbonic acid whose composition, as well as that of ellagitannic acid, has been made known by Meunier.[1] I will add that the formula of gallotannic acid as stated in works upon general chemistry and upon the art of tanning has been much discussed because of the fact that this acid, which is obtained by synthesis, is not optically active, while tannic acid, which is obtained from natural pyrogallic tannin, affects, on the contrary, polarized light. . . . Nierenstein regards tannin as very different from ellagic acid from the fact that the first when distilled with zinc powder gives diphenyl—methane $C_6H_5\ CH_2\ C_6H_5$ while in the same conditions the second gives fluorene $\begin{matrix} C_6H_4 \\ | \\ C_6H_4 \end{matrix}\!\!>\!CH_2$

By acetylizing tannin we obtain two different products, one of which pent-acetylate, melts at 203° C., while the other, hexacetylate melts at 116°C. He believes tannin to be composed of a mixture of gallotannic acid which yields pent-acetylate and its reduction product, the leuco-derivative, which yields hexo-acetylate, and that it is this leuco-tannin which causes the activity of the natural product.

Catechic tannins.—These are derived from pyro-catechin, and some of them, perhaps, from phloro-glucine; they are sometimes found mixed with pyrogallic tannins in natural products. To these are added the extracts from the bark of the oak, beech, pine, hemlock, mimosa, and mangrove, as well as the tannin from the quebracho, the gambier, the cachetu, etc. These also behave differently with respect to the hides, varying even more perhaps since they are associated with a larger number of foreign substances; among these we may especially mention:

a. The catechins, the hydrolytic products of these tannins. These are slightly soluble in cold water. Perkins has isolated and studied the catechic tannin of the gambier, which he obtained crystallized with four molecules of water, its formula being $C_{15}H_{14}D_64H_2O$;

b. The phlobaphenes, which are the products of condensation, on the contrary, and which proceed from the de-hydration accompanied by oxidation of the catechic tannins. Each tannin posesses a series of these anhydrides, and the further dehydration is carried the less soluble and the more highly colored they are.

Among the catechic acids the most important include (1) the quercitannic acid of oak bark, which forms derivatives with bromium and fixes 28.4 per cent of this substance; this acid is also found in the bark of the mimosa.

(2) Quebracho-tannic acid, which fixes 43 per cent of bromium.

(3) Cachou-tannic acid, which fixes 50 per cent of bromium.

Finally, there may be mentioned among the tanning substances found in this group coloring products having a constitution which is quite complex; these are called flavones.

None of these catechic tannins has been isolated in the crystalline state and pure, and no one has any exact idea as to their structural formulas. All one can say is that they have excessively high molecular weights. Koerner found the molecular weight of the tannin of the quebracho to exceed 1,000. According to Paterno, these weights may vary between 2,500 and 3,500. It results from this that the tannins exist in water in the form of a colloidal solution. They are much better absorbed by the hydrogels when they are in the form of an aqueous solution than when dissolved in other vehicles. Wislicenus has proved that in certain conditions tannin is absorbed by nascent alumina in the proportion of 78 per cent, while in an acetic solution the proportion is only 32 per cent. Koerner also found an absorption of 99 per cent for

The significant statement was recently made by an important English journal dealing with the leather trade that the great German dye-works, the Badische Anilin und Soda Fabrik is still taking out patents for further products based upon Stiasny's invention of Neradol, being evidently convinced that there is a dazzling future in store for synthetic tanning material, which will probably prove to be "as big a gold mine as synthetic indigo."

They add: "There is in addition a German patent No. 262,558 which appears to cover a very wide range of substances capable of converting animal skins into leather." The French chemical journal, Chimie et Industrie, in commenting upon this statement, remarks that while it is true that the great German chemical works has continued during the last two years to take out new patents upon sulphonated products to be used in tanning it is by no means certain that it is in this direction that the industry of "synthetic" tannins will develop. Without pretending to decide as to the merits of these two views we are of opinion that the subject is one of great importance and interest, both on account of the ominous rise in the cost of leather, for whose various applications no entirely satisfactory substitute has even been found, and because of the steady diminution in the sources of supply of natural tannins. We are, therefore, glad to present to our readers the following discussion of the matter by a distinguished authority.—EDITOR.

*Translated for the *Scientific American Monthly* from *Chimie et Industrie*, Paris.

[1] *Chimie et Industrie*, 1918, vol i, No. 1, page 75.

quebracho tannin in an aqueous solution and only 53 per cent in an acetic solution.

Prof. Procter, who has studied the phenomena of tanning quantitatively, has shown that the difference of potential which exists between the superficial layer of the micellary particles of tannin and the mass of the solution, diminishes in proportion as the concentration of the electrolyte augments. When this difference becomes very small the tannin begins to become flocculent and since the micellae of gelatine and of the skin substance have precisely opposite signs this authority believes that it is the electric neutralization of the particles in contact which produces the co-precipitation of the two colloids, thus causing the fixation of the tannin upon the skin, and also the absolute insolubilization of the fibre thus transformed, which appears to be due to phenomena of a different kind.

As a matter of fact it has been thoroughly demonstrated that the vegetable tannins are colloids, and this being true it is believed that there can be no question of obtaining by synthesis compounds which are *identical* with the natural tannins.

RECENT SYNTHETIC STUDIES IN THE GROUP OF TANNINS AND THE PROBABLE ACTUAL CONSTITUTION OF PYROGALLIC TANNINS.

The formula of digallic acid has long been attributed to the tannin obtained from gall-nuts. Walden observed in 1897, that the natural product differs from tannin acid by several of its physical properties, in particular by its electric conductibility and by its behavior with respect to light. Moreover, arsenic acid exerts a different action upon the two products, and the molecular weight of tannin is manifestly higher.

Nierenstein suggested that natural tannin might be a mixture of digallic acid and its optically active reduction product. leuco-tannin. But such a mixture ought to be more acid than the natural product and ought to have apparently a lower molecular weight.

Fischer has made progress in the study of this question, as shown in his various works published between 1906 and 1913. He began by purifying the natural product obtained from Chinese gall-nuts, by eliminating the compound containing free carboxyl groups by means of ethyl acetate; in this manner he obtained an optically active product. He next studied the products of hydrolysis obtained by the acid method. He found that pure tannin decomposes into one molecule of glucose and ten molecules of gallic acid. This would indicate that the natural substance is an ether compound composed of five molecules of digalic acid and one molecule of glucose.

Fischer attempted the synthesis of the corresponding gallic compound. The operation was not possible by means of the ordinary process, proceeding by means of the chloride of the acid since the clorine of the cloride of phosphorus bears the same relation to the phenolated OH groups. He began by fixing the OH groups of gallic acid by the chloride of acetyl.

The carbo-methoxy derivative thus obtained by the elimination of hydrochloric acid is sufficiently stable to permit the reaction of the chlorine upon the carboxyl group. It should be easy consequently to reconstitute the hydroxyl group by expelling the carbo-methoxyl groups by means of slow hydrolysis. He, therefore, caused the chloride of the acid to react upon the glucose in a chloroformic solution by employing quinolein to fix the hydrochloric acid form, which gave him the penta-tricarbo-methoxy-gallate of glucose. . . .

The compound thus obtained was saponified by a slight excess of alkali dissolved in an aqueous solution of acetone. under these conditions the carbo-methoxyl groups are removed at ordinary temperatures and the penta-gallate of glucose is isolated. This compound is very similar to tannin, different from it, however, by the fact that it exerts no action upon light.

Herzig undertook the synthesis of methylo-tannin and obtained by hydrolysis tri-methyl-gallic acid on the one hand, and on the other the a-symmetrical m-p-dime-thyl-gallic acid.

These facts cause us to suppose that tannin is an ether of glucose with five molecules of m-digalic acid. However, it is possible that these compounds which enter into combination with the digallic acid are poly-saccharids, and that the glucose is produced only by the hydrolysis of these compounds. The different products prepared by the preceding method, by means of various hydroxy-acids and of saccharids, possess characteristics analogous to those of the tannins. However, up to the present time no one has been able to prepare these substances at a price even remotely approximating that of natural tannins. Substitutes alone have been put upon the market.

PRACTICAL DEFINITION OF THE SO-CALLED "SYNTHETIC" TANNINS

The word tanning as used in industry signifies the transformation of hides in which leather, *i. e.* an ensemble of transformation whose object is to render the hide non-putrecible, non-sensitive, or but slightly sensitive, to the action of water and of dilute chemical substances and not rapidly affected by bad weather, etc., while at the same time preserving a certain degree of flexibility (which varies according to the kind of leather), a certain degree of elasticity of the original tissues, and a sufficient amount of resistance to traction, etc.

Substances capable of producing these results are numerous and very varied. They include, in particular, besides the natural tannins, fatty substances, formol, and a large number of mineral substances, especially the salts of cromium, of aluminum, of iron, of zinc, of sulphur, of silicon, etc. In the industrial sense of the word all of these products are tannins. It is not strange, therefore, that investigators have sought in the group of phenolated compounds substances capable of causing the same results.

The first researches along this line were made by Prof. Mennier, of the University of Lyons. The process of tanning by means of quinone, which he perfected, was in use in France and Germany before the war. Prof. Stiasny of the University of Leeds endeavored to prepare by synthesis phenolated compounds of a more complex character, with the object of obtaining compounds more closely resembling the vegetable tannins. He manufactured a substitute which the *Badische Analin und Soda Fabrik* patented under the name of "Neradol D," which was employed in Germany and particularly in England. These two compounds can be obtained simply and easily as by-products and may even occur as residues in the utilization of substances derived from the distillation of coal which the allied countries propose to continue to treat in large quantities after the war. . . .

ACTION OF QUINON UPON GELATINE AND UPON SKINS. MEUNIER'S RESEARCHES.

a. Action Upon Gelatine.—In 1908 Meunier and Seycewitz published their researches concerning the insolubilization of gelatine by the action of the following organic compounds: phenol, resorcine, orcine, hydro-quinone, pyrocatechin, gallo-tannic acid, pyrogallol, paramino-phenol, chloro-phenol, picric acid, adurol (mono-chlor-hydro-quinone), the beta-naphtol-disulphonic acids (R. G. acids), and beta-naphtol-mono-sulphonic acid (S. acid). . . . The phenols, which are only slightly soluble in water, such as the alpha and beta naphtol (not more so than the amines), the amino-phenol, simple or substituted, whether in the state of free bases or in the state of salts, do not yield a precipitate in gelatine solution.

When the precipitation occurs under conditions favorable to oxidation, the phenol and even the amino-phenols yield precipitates which are insoluble in boiling water. The discovery of this fact led investigators to test the products of the oxidation of the phenols. The quinones and particularly ordinary quinone were especially tested in this regard. They found that "quinonated gelatine constitutes the most stable form of insoluble gelatine thus far known," since it resists

not only the action of boiling water but also that of dilute acids and alkalis.

The non-solubilization occurs with extreme rapidity . . . having been obtained even in less than two hours at 15° C. The quin-hydrones act in the same manner, but more slowly. Experiments with formaldehydide, on the contrary, yield a product which dissolves totally in hot water upon repeated treatments and which decomposes under the action of a high heat into formaldehydes. This product is dissolved by a cold hydrochloric acid at 15° C. and by dilute alkalies.

b. Action Upon Skins.—The same results were obtained with the phenols and the amino-phenols in the presence of oxidizers as with the quinone compound employed with oxidizers. Comparative tests of other compounds capable of affecting dermic tissues have led to the conclusion that a quinone solution containing only one part of quinone for every one hundred parts of raw skin will insolubilize the tissue and transform it into leather whose resistance to the action of water, alkalis and acids is superior to that of all other known leathers, including the chrome leather, and whose resistance to friction is, at least, equal to that of the above leathers tanned by oak bark.

The analysis of the baths used has demonstrated the presence of hydro-quinone, which proves that a portion of the quinone has served to oxidize the skin substance, while the rest of it is combined in a stable manner with the oxidized skin. But hydro-quinone is eminently oxidizable and the yield would be better if one could succeed in reoxidizing it. Hence all conditions which favor the absorption of oxygen, likewise favor tanning. The use of catalyzers (laccasses, artificial peroxy-diastases, the acetates of manganese, of cerium, of lanthanium, etc.) will make possible, therefore, a quicker and more perfect utilization of the quinone. Meunier also observed that oxydases which are found among the soluble matters are given up by the skin during the process of tanning.

PROPERTIES OF QUINONE AND METHOD OF OBTAINING.

The quinones in general are obtained by the oxidation of the corresponding para-diphenols. They are also produced when the OH groups number more than two, provided that two of them exist in the para position. They are formed by the oxidation of a large number of compounds derived from the phenols, *e. g. p*-phenol-sulphuric acid or other amino-phenolated compounds, such as *p*-amino-phenol; but they are likewise formed by means of certain mono-substituted derivatives of benzene, such as analine. It is this process which is used in laboratories for the preparation of ordinary quinone, chromic acid being the oxidizer.

Among the principal properties which influence tanning are the following:

Quinone is only slightly soluble in cold water (0.5 per cent). It dissolves better in hot water and in acidulated water. In practice it is dissolved in slightly acid boiling water . . . but the operation must be performed in a closed container since the product is very volatile and is easily carried off by the steam. Acid solutions remain unaltered longer than either neutral or alkaline solutions, especially the latter. Light is unfavorable, facilitating oxidation. Quinone solutions must not come in contact with metals or wooden containers when the latter contain tannin or when the vat has been previously used for tanning with vegetable tannins, since otherwise their color will become much more intense and they will lose their property of producing a light tan. Quinone keeps well in the crystalized state in wooden or tin containers *when dry*. It is preferable to prepare the solution beforehand, making sure that they contain no undissolved quinone.

Application.—Quinone alone will tan the hide completely in a few days, 1.5 parts of quinone being employed for 100 parts of raw skin. At first sight it would seem, however, that quinone tanning is the ideal process both because of its rapidity and because of its cheapness. However this is not true in the present state of the leather market. Aside from a few kinds of light leather . . . leathers are sold by weight. This custom was established at a period when the raw skins could be bought at a price moderately higher than that of the tannin. . . . Since then the situation is changed—green hides with the hair on are sold at a formidable price, and the disproportion between its value and that of the unit of tannin . . . has become considerable. The result is that leathers, especially those made by rapid processes, contain more or less combined or non-combined tannin, so that many of them often contain no more than 30 to 35 per cent of the substance of the hide itself. Under such conditions quinone tanning cannot compete with tannin by vegetable extracts, except in the case of light leathers which are sold by the square foot. . . . The chief use of quinone in fact is for *pre-tanning*.

Even before the discovery of quinone formol was used for the pre-treatment of leather in order to isolate the fibres from each other and give them the desired firmness and resistance, enabling them to bear the action of the highly concentrated solutions used in rapid tannin. The formol does not persist in the leather and experience has shown that after being stored for a few months these leathers become brittle. Quinone does not produce such an effect and the hides treated with it fix the vegetable tannins with remarkable rapidity without affecting unfavorably either the leather or the modern rapid process, hence its use has rapidly spread . . . especially in the tanning of sole leather.

Quinone pre-tanning is used in preparing strap leather as well as heavy leather and glossy leather, experiments having shown that this treatment enables it to undergo resistance to traction longer than usual. It is also used for vamp leather and for leather prepared by vegetable tannins as also in mixed tanning together with chrome.

In preparing box calf . . . the quinone is applied in the presence of lactic acid, 600 gr. of quinone and 300 gr. of 80 per cent lactic acid, applied three times, being sufficient for 100 kg. of hide. If the hide has undergone the bran treatment the lactic is useless; acetic acid is better for the ordinary leathers mentioned above.

Chrome tannin is obtained in a bath, the quantity of chrome generally employed being reduced to 6/10 of the amount. The amounts of borax, of sodium bicarbonate, or of the ammonium mixture required for neutralization are likewise reduced in the same proportion.

Black box calf thus produced has the following advantages:

1. The leather is more pervious to air, making cooler and more hygienic shoes.

2. It is more pliable and the bloom is finer. . . .

3. The black color is more uniform, not only in the different parts of the same hide but also in the same lot of hides which increases the percentage of first class leather. To produce the box calf color the proportions required of sumac and of gambier can be greatly reduced, and the bloom is never either hard or brittle. The same thing is true of glossy calf, either black or colored. Finally the tanning of kid skins for shoes can be performed in a bath and the application of the color does not require previous testing.

NERADOL-D, OR SYNTAN.

The Work of Stiasny.—Stiasny's purpose was not merely the replacing of natural tannins by other tannins (industrially speaking) of much simpler character like quinone, but the preparation by synthesis of substances resembling natural tannin as closely as possible.

Such products must have a well defined composition which can be modified at will by the introduction of new alkyl groups, with the view of manufacturing an entire series of tannins specially suitable for obtaining all known varieties of leather and even other kinds as yet unknown. The use of these tannins, to which the inventor gave the name of "syntans," was intended to remedy the more or less empirical character of tanning by vegetable tannins . . . by producing compounds of known composition and definite action.

Stiasny presented his first communication upon this sub-

ject in 1913 to the London Society of Chemical Industry, of which paper we here give the following abstract:

The syntans are products of condensation. They are obtained by heating the phenols with formaldehyde in a slightly acid solution and then rendering insoluble the resinous substances thus obtained by the action of sulphuric acid. They can also be prepared by sulphonizing the phenols and then condensing them with formaldehyde under such conditions that products soluble in water are alone obtained. According to the inventor the condensation process properly consists in the formation of a derivative of diphenyl-methane, which by polymerization leads to the formation of molecules having a high molecular weight, which fact imparts its amorphous character to the product.

Syntans resemble in aspect tannin extracts but are less highly colored. Their aqueous solutions are semi-colloidal and traverse semi-permeable membranes only with great slowness.

They precipitate gelatine. Together with salts of iron they produce a deep color. They are precipitated by lead acetate and by hydro-chlorate of aniline. Finally they tan skin like true tannins.

Neradol-D (which up to the present time is the principal product put upon the market) when employed alone yields a very pliable leather, having a characteristic light color. It is used in combination with other tannins for the pre-tanning of heavy leather in the same manner as quinone. Like the latter it protects the bloom which it tans slowly; the latter does not break after tanning with strong extracts and it is but slightly sensitive to the later action of light. Finally it accelerates the process of tanning and does not interfere with the yield by weight. . . . Its use is recommended for the re-tanning of Indian sheep-skins and also for simultaneous employment in chrome tanning.

The author here comments upon the lack of detail given by Stiasny, remarking significantly that in 1912 *he had sold his patent to the "Badisch Company, Ltd.," which firm placed the product upon the market under the name of Neradol-D.*—EDITOR.

PREPARATION OF THE SYNTANS.

At the beginning of the war the German-made Neradol-D disappeared from the English market. It was then noted that it had enjoyed a very wide use and products were thereupon prepared from the data given in the patent, which differed considerably from each other according to the manufacturer. The color of these products varies from red-brown to black and the consistency from the fluid to the pasty condition. All of them contain non-soluble substances in considerable proportions and appear to behave in practice like Neradol-D.

The raw materials used consist of cresol C_6H_4 (CH_3) OH (which is found in coal tar), sulphuric acid, formol, and caustic soda.

The testing of these substances is quite easy except as regards crude cresol which not only contains the three isomers of this body, but also variable quantities of other phenols, of pyridin, etc. The latter remains in the form of the sulphate during the operations and does not influence them.

The manufacture occurs in three phases—sulphonation, condensation, and neutralization . . .

a. Sulphonation. A mixture of equal weights of cresol and sulphuric acid is heated until complete sulphonation occurs . . . The time required varies from 1½ to 8 hours according to the nature of the raw material, temperature, etc. . . .

b. Condensation.—This process, which is performed in the cold, is slow and tedious, and it is difficult to tell whether the reaction occurs under good conditions. All that can be determined positively is the complete disappearance of the phenol odor which is replaced by the vapors of formaldehyde.

The sulphonated product is then cooled, after which formol is poured into it *very slowly during continuous stirring*, care being taken to keep the temperature below 35° C. and regulating it either by a worm or by a double wall wherein water or some other liquid, kept as cold as possible by a freezing machine, circulates. The addition to the solution of formaldehyde causes a considerable rise of temperature, both because of the heat developed by the reaction and because of its mixture with the concentrated sulphuric acid thus produced.

The substance obtained is very viscous, and has a dull brown color of a slightly redish cast. This is hygroscopic and must be neutralized without too great a delay.

c. Neutralization.—The product contains about 25 per cent of acid calculated in sulphuric acid. It is partly neutralized so as to reduce the acid approximately to the content of a normal solution, i.e. 4.9 per cent of sulphuric acid. The quality of soda solution required must be calculated separately for each vat. The heat developed by the reaction is considerable; hence the soda solution must not only be added very slowly with constant stirring but the mass must be cooled externally as described. Under these conditions the liquid clears up greatly and loses a large part of its viscosity.

It is possible that by causing the temperature of the neutralization to vary as also the concentration and the proportion of the soda solution, secondary reactions are made to take place which produce changes in the nature of the compound obtained to such an extent as to cause a greater or less degree of variation in the latter's properties. . . . At any rate compounds are obtained which, while behaving similarly to Neradol-D differ considerably with respect to the results obtained in tanning. Some of the products manufactured in England are, in fact, superior to Neradol-D, yielding leathers which are whiter and more pliable although equally resistant. Furthermore, these products are capable of penetrating the calf skin in the course of only a few hours.

The author here quotes an abstract of certain articles published in "The Leather World" with regard to different practical methods of the employment of these products. Since these are not necessary to the comprehension of the scientific aspect of the subject, we omit them in this place.—EDITOR.

THE FUTURE OF SYNTHETIC TANNINS.

The so-called synthetic tannins, quinone and syntan, have permitted the obtaining during the war of leathers of good quality by rapid methods. Such methods have been almost completely substituted for the older methods over which they present many and important advantages. It cannot be doubted that these new methods will continue to make progress in the future. . . Since 1914 the allied countries have enormously developed the industry of coal tar and its derivatives, their object being to prepare explosives in the first place and secondly the dyes and medicines formerly furnished by Germany.

It is probable that the industry of derivatives of coal will continue to be extended after the war and that raw materials for the manufacture of synthetic tannins will be obtainable in abundance and at a fair price. . .

* * * * * *

It must be mentioned, however, that the technical reviews have frequently referred to the difficulties encountered in the manufacture of leathers by the use of syntans. In Germany in particular the authorities have even gone so far as to prohibit their use in the manufacture of leathers to be used for the army. Furthermore, the latest researches concerning natural tannins and particularly those made in Germany, seem to prove that these substances contain quinonic groups, which play the principal part in tanning. According to Moeller (*Collegium* 1918, pp. 71-78) all the various kinds of tanning possess points in common with quinone tannin and all the tannins have a quinonic character.

The phlobaphenes of quebracho, in particular, yield anthracene, when distilled with powdered zinc, and more than ten

years ago Nierenstein ascribed this reaction to the presence of a hexa-oxyanthraquinone. Powarnin discovered oxy-anthraquinone in the tannin of willow bark, which is a pyrogallic tannin. As a matter of fact all of the phlobaphenes formed by the dehydration and oxidation of tannins contain quinonic groups in their molecules.

All tannic extracts contain these compounds, which are kept in solution by the pepsinizing action of tannin. When the latter is oxidised the colloido-chemical character of the solution changes. Certain pepsinized phlobaphenes are precipitated at the same time as the black humic substances proceeding from a more profound dehydration. The latter are partially absorbed by the phlobaphenes remaining in solution, which is the cause of the deepening in color of the liquid. Furthermore, the soluble pepsinizers are converted into colloidal substances closely resembling the phlobaphenes. As an intermediary product of this oxidation one always finds benzo-quinone, the quin-hydrone which imparts to the solution an intense red color, a hue which is often attributed to the phlobaphenes themselves.

According to Moeller any oxidation of the pepsinizers in solutions of vegetable tanning substances will yield, as intermediary products, quinonic compounds, and these compounds may even be preexistant in the plants themselves. But substances, having a quinonic character possess in a high degree the property of forming coloidal pepsinized solutions, and are, in reality, the true and only tanning substances capable of uniting with the fibres of the skin permanently. The facts stated in the foregoing remarks, as well as the present concept of the nature of the art of tannins appear to indicate that the quinone process constitutes the method which accomplishes in the simplest and probably in the most rapid manner, those phenomena which take place in the process of tanning by means of vegetable tannins.

INDUSTRIAL APPLICATIONS OF HELIUM

THE rare gas helium was long considered of merely scientific interest because of its scarcity and the great expense of its production. In the last few years, however, helium has been found to be present in the emanations issuing from numbers of hot springs and in the explosive gas, often present in mines, known as fire-damp, or in so-called natural gas. Furthermore, the war has given a tremendous impetus to the study of helium and the effort to produce it more cheaply than was possible while it remained a mere curiosity of the laboratory. The reason for this, of course, is the fact that it is admirably adapted for the filling of the gas bags of dirigibles and other balloons, because of the fact that it is non-inflammable and non-explosive like hydrogen, which has hitherto been empolyed for this purpose. Helium is likewise very light, only about twice as heavy as hydrogen, which is the lightest of all known substances. One liter of helium weighs 178 millograms.

The ascensional power of helium is about 92 per cent. that of hydrogen. This comparatively small diminution of power is practically insignificant, being largely compensated by only half as much diffusion through textiles. Another valuable property of helium resides in the fact that it can be more readily traversed by electric discharges than is the case with most gases. For this reason an appartus may be employed inside the aerostat to heat the gas by electricity and in this manner by modifying the volume of gas it is possible to vary at pleasure the ascensional force, which is of course eminently useful.

Up to a few years ago only two or three cubic meters of helium had been produced and the cost was something like $40,000 per cubic meter. Recent achievements in the production of helium in this country and elsewhere are interestingly summarized in a recent number of Larousse Mensuel (Paris), from which we abstract the following remarks:

At the instance of an engineer named Cottrell well known in France through his work concerning the collection of dust by electricity, important plants were erected in 1918 in the United States for the extraction of helium from natural gas. These efforts were so successful that when the armistice was declared 5,000 cubic meters of helium were ready to be delivered for use in military balloons. The gas from which this helium was obtained was found in a well at Petrolia, Texas, having a daily flow of 700,000 cubic meters of natural gas. This gas (which is composed chiefly of methane) contains 0.9 per cent. of helium. It is piped a distance of 150 km. to Fort Worth and Dallas.

The helium is separated out by a process of liquifaction in the same manner in which liquid air is produced. The three methods in practice, those of Claude, Linde, and Jefferies-Norton were employed in three distinct plants, in order to determine which process was most advantageous. These plants succeed in producing helium 93 per cent. pure. The purified gas is used for fuel while the helium is compressed and stored in steel tubes.

It is to be hoped that this interesting experiment will not be arrested by the coming of peace. It is reported, indeed, that projects are on foot in America looking towards the annual production of 500,000 cubic meters of helium and an accompanying reduction of the price to less than four dollars per cubic meter.

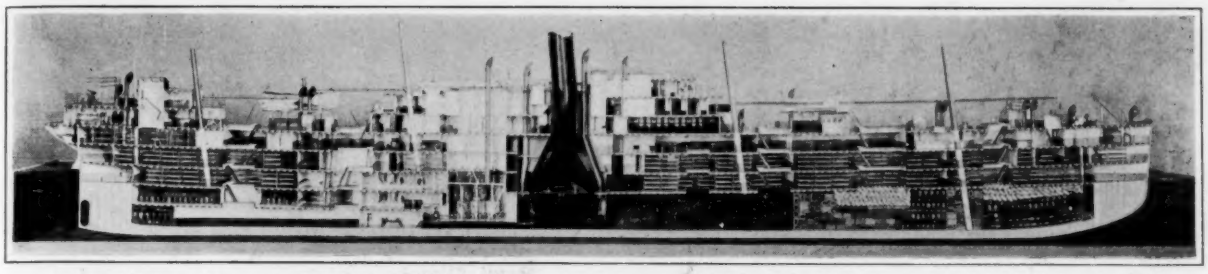
The production of helium at practical prices is closely dependent at present upon the development of the dirigible. The latter loses one per cent. of its contents per day through diffusion, which makes it a steady customer, so to speak, and raises the question of where sufficient supplies of the gas can be obtained. We have already spoken of natural gas as a source in this country. In France Prof. Mouren has shown that considerable amounts of helium exist in the gases issuing from hot springs, sometimes as much as 10 per cent. It is also found issuing from the ground in volcanic regions, and such supplies may perhaps be regarded as practically inexhaustible.

A practical difficulty arises, however, with regard to the production of helium which may be stated as follows, If production from natural gas is deferred until the helium is actually required this involves deferring the use of the natural gas as a combustible—and this at a time when it is more needed than ever; on the other hand if the helium is extracted and stored till wanted the cost of storage would be prohibitive.

According to the writer of the article in Larousse, the solution of this dilemma must be sought either in the promotion of the commercial use of the dirigible or in some new application of helium which will increase the demand for it. Not long ago M. Claude, whose name is well known in connection with the liquifaction of air, having proved that the atmosphere contains three parts of neon and one part of helium in 200,000 parts of the atmosphere, conceived the idea of making use of the helium by employing it to drive a motor by means of expansion, and thus being able to obtain in practice temperatures very close to the absolute zero.

At such temperatures the physical properties of bodies are so greatly modified that numerous practical applications may be derived therefrom—a typical example is the reduction of electric resistance to one-ten-millionth of its value. Furthermore, these endeavors to produce helium in practical quantities may have the happy result of facilitating the producton of oxygen, thanks to the improvement made in liquifaction processes.

Hitherto oxygen has been so costly that its use has been restricted to certain special purposes, such as welding, perforation, the blow-pipe, etc., but if it could be furnished to manufacturers at a reasonably low price it is confidently predicted that a revolution in metallurgical processes would ensue, and that we might have furnaces fed with oxygen instead of with air. Thus helium furnishes us with another example wherein pure science serves as a handmaid to practical industry.



A HALF MODEL OF THE "GENERAL SHERMAN," SHOWING THE INTERESTING DETAILS OF A GOVERNMENT TRANSPORT. QUITE TEN THOUSAND PIECES WENT INTO THE MAKE-UP OF THIS MODEL

Ship Building in Miniature

Important Part That Models Have to Play

By Robert G. Skerrett

(Photographs copyrighted by the Keystone View Co.)

SHIPYARDS on the waterfront are matters of commonplace, but a marine construction plant tucked away high above bustling thoroughfares is, indeed, something of a novelty. And yet, in a tall loft building on lower Manhattan, in Greater New York, is an establishment where all kinds of craft that float, from small boats to superdreadnaughts, are turned out complete in every detail.

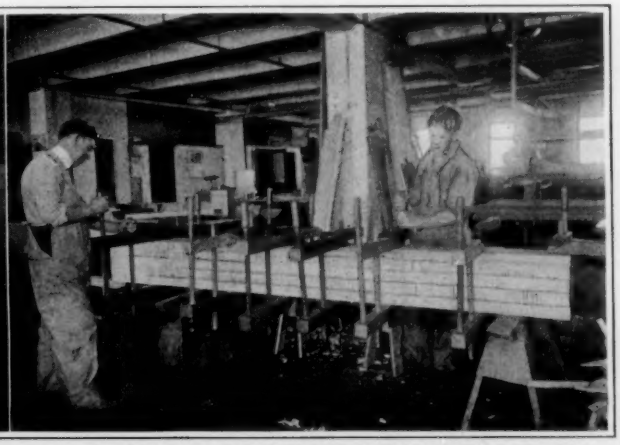
More than that, there is no other shipyard in the whole country boasting departments enough to supply on the spot, as the concern in question does, the multiplicity of things needed from the time of the laying of the keel until the fluttering colors at masthead and peak indicate readiness for service. True, the vessels produced are not designed to defy storms and to force their way onward against pounding seas, but in their way and field of usefulness they are not disassociated from their water-borne kindred that do battle with the changeful elements. Lest the foregoing mislead, let it be said that we are speaking of nautical models, of the naval architects's creations in miniature.

Popularly, the model of a ship is looked upon more often than otherwise as an expensive toy—a plaything in a measure that may be extremely ornate and decorative but in no wise of practical value. The gentry that count their pennies over carefully are prone to ask, "What's the use of the thing?" And then positively dismiss the matter with the vocal protest, "All a waste of money!" For the sake of those likely to be influenced by this hasty attitude, it might be well to go back two or three centuries for a start and then trace the evolution and the reason for being of miniature replicas of ocean-going craft of all sorts. We shall see that the utilitarian impulse has played a prime part for a long, long time while in their fabrication.

In the days when the British Admiralty was first busy upbuilding the nation's sea might, in the generations gone when the naval architect boasted no more exalted title than master shipwright, the authorities would have thought they were tempting Fate to start the building of their "oaken bulwarks" without some concrete evidence of how their frigates and their line-of-battleships would look when finished. Indeed, they would hardly have known how to carry on correctly the work of construction unless guided by a model in detail. It was this practice that brought into being the myriad models that now adorn the home of the Admiralty and certain British museums. These miniatures were for a considerable period the basis of such plans as were prepared, and furnished certain information of their own by which the ship carpenters and the shipwrights of those days could visualize just what they were expected to do.

To this end, little was left to the imagination, and a deal of painstaking care was exercised in developing on a much-reduced scale every important structural feature. Therefore, the outside planking on one-half of the hull below the waterline was pretty generally omitted so that the frames, the keel, the keelsons, the floors, the deck beams, etc., could be seen in their true relation to one another, and each with its distinctive shape agreeably to its position in the complex

CHECKING UP THE HULL CONTOURS WITH A TEMPLATE REPRODUCED FROM THE BODY PLAN



FORMING THE MASS OF "BLOCK" FROM WHICH THE HULL OF A MODEL WILL BE WORKED

PUTTING THE FINISHING TOUCHES ON THE MODEL OF A CONVERTED YACHT WHICH PLAYED A PART IN THE WORLD WAR

PAINTING WAR TIME NAVAL MODELS—ONE OF OUR BIGGEST SUBMARINES AND AN UP-TO-DATE DESTROYER

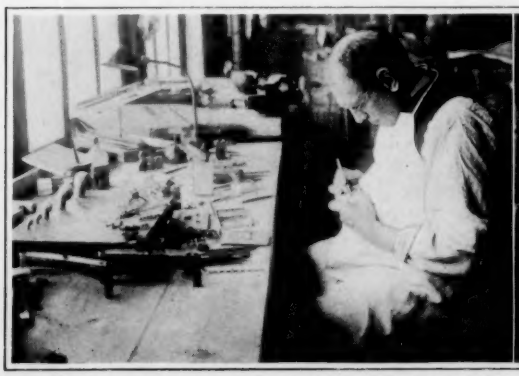
framework. On the other half, the planking would possibly be complete from the keel to the upper limits of the hull. And thus the "lines" or contours essential to flotation and relative ease of propulsion under canvas could be measured and reproduced on the mold-loft floor so that the man with the broad-ax might fashion his timbers for the full-sized vessel.

The model maker was a product of the period and, as often as not, was a qualified shipwright who possessed special skill in the handling of refined tools. He would take his block of wood or materials and lovingly and patiently work them into shape—grace of line and accuracy of detail being the result of an experience which made him familiar with the body forms which would give adequate speed and seaworthiness. At a later date, as a knowledge of interpreting drawings grew, the advance model became a simpler product, because the shipworkers were not so dependent upon miniature details. It was then sufficient to supply a solid half model, showing the outer aspect of the bare hull from stern to stern and from the keel up to the exposed decks. From these half models, the men of the mold-loft developed the lines and contours of the craft's body, and, so guided, the woodworkers fashioned templates or patterns for the multiple elements of the structural framework.

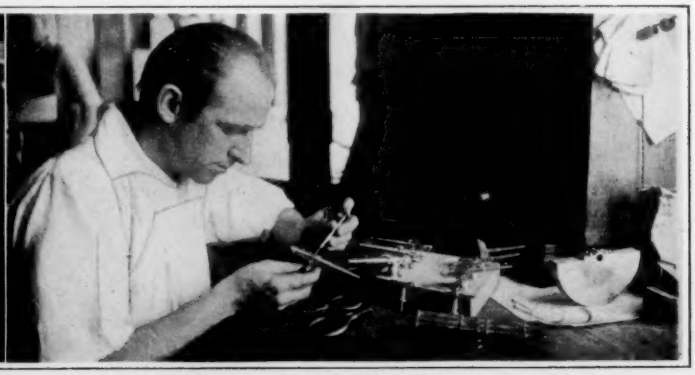
These half models were fashioned out of a built-up block composed of successive layers of wood of equal thickness held together by dowels, the meeting surfaces of two contiguous "lifts" representing a waterline at a definite point above the keel. After the block had been cut and chiseled into the desired form, then it was an easy matter to take the model apart, layer by layer, and transfer each waterline to paper. With this done, the ship carpenter could readily check off the dimensions at every point on the hull and make the full-sized part in accordance. With those half models as basic records, and with the knowledge of how the actual craft later performed, the designer of those days was able from time to time to effect improvements despite the fact that his procedure was so largely a matter of "rule of thumb." Native cunning and intuition, a cultivated appreciation of "sweetness of line" through feeling, and a keenness of eye made the model then a potent aid in the building of ships.

As the science of naval architecture advanced, the designer was inclined to belittle the value of models, and, because of his wider knowledge of mathematics and the technical development of graphics, he came to rely wellnigh entirely upon paper and pencil. During the prevalence of this attitude many disappointing vessels were put overboard, for somehow either the lines were not faithfully reproduced in the yard or, if they were, they disclosed the fact that the man originally responsible for them could not visualize the consequence of his choice. It is a rare mind that can picture the third dimension from lines that symbolize only length and breadth, for instance. It was inevitable that shipbuilders should come to realize that much might be gained by combining the stories to be told by both drawings and models. This was quickly emphasized when iron, and, later, steel more and more took the place of timber in the fashioning of waterborne craft.

The modern ship, whether naval or commercial, is made up of assembled plates, angle bars, and beams of steel. Knowing as the ship designer does today how much may depend upon a vessel's form in the matter of speed, and the propulsive effort needful to attain it, mere drawings, with all of their elaborateness, are no longer accepted as conclusive. Therefore wooden models are made not only for testing in towing tanks but others, scaled usually to a quarter of an inch to the foot, are produced to facilitate certain essential calculations and to enable the "office" to order the hull plating, etc. Naturally, these models must be fashioned with precision, for any error would be multiplied forty-eight times in every foot of the intended craft. The models also serve to give the designer a three-dimensional appreciation of his problem and aid him in securing that balance of



THE METAL FEATURES OF A MODEL REQUIRE THE SKILL OF AN EXPERT MACHINIST



THE MINIATURE GUNS OF OUR FIGHTING CRAFT MODELS ARE WONDERFULLY COMPLETE IN THEIR OUTWARD DETAILS

mass and features essential to strength, correct functioning and appearance.

As experience has taught us, it is not difficult to draw a circle and to say that it represents the outline of a globe, but it is quite different to decide from that figure just how to proportion and to shape a single piece of material that can be bent or pressed into the form of a sphere. Of course, if you have a ball upon which to fit your pattern a little practice will enable you to do the trick. The external plating of a vessel is the skin that must conform to the changing lines and contours dictated by the underlying steel ribs or frames, and this plating, in multiple units of divers forms, must be ordered in advance of construction.

A properly-scaled wooden model of the hull of the craft to be, with sandpapered unpainted surface, is turned over to some of the drafting force, who indicate on the bare pine every plate from bow to stern and from keel to sheerline. It is then a relatively easy task to take off the "expanded" dimensions of curved surfaces and to give their measurements as flat plates. These figures are then sent to the steel mills where patterns are made and the plates are cut accordingly. Later, when they reach the yard, these parts are heated and hammered or otherwise bent to fit. By means of the wooden model and the advance measurement of materials which it makes possible, the naval architect computes what all of this steel will weigh, and this enables him to determine the ultimate displacement of his craft and to estimate pretty closely some of the costs.

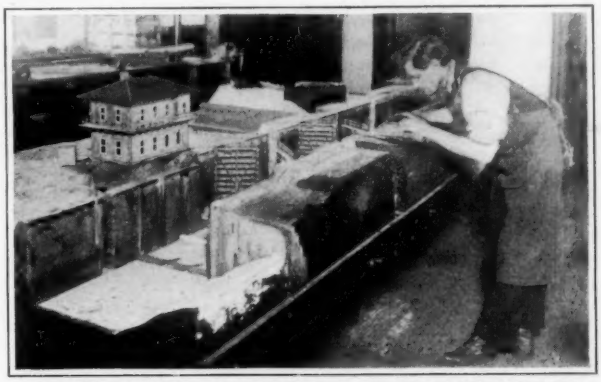
Subsequently this bare model of the hull is carried a stage further and some of the dominating deck features, etc., are put on. If a fighting ship, this procedure is very desirable because it enables the designers to determine quickly the possible angles of fire of guns without inviting interferences with other necessary structural parts. In short, it gives positive information about interrelated characteristics and makes it practicable for the naval architect to avoid mistakes that may later on entail heavy outlays to correct. Similarly, in the cases of merchant and pleasure craft, by following much the same course, vessels can be planned confidently so as to insure a maximum of comfort to passengers and convenience to the personnel operating them.

It has been the custom wellnight since the birth of our modern navy to employ models of the foregoing description and, after they have served the designer's purpose, to complete them and finish them outwardly as miniature replicas of their service kin. The object has been twofold: first to record thus in the most expressive way the development of our battle fleet and the gradual growth of the distinctive types of war craft—the adoption of a uniform scale of a quarter of an inch to the foot facilitating accurate comparison in the matter or sizes. For some years, all of these models were made at the Navy Yard, Washington, D. C., but now some of them are being built at the plant in New York City over which Mr. Horace E. Boucher presides. This expert—one may rightly say of this artist—was for a number of years in charge of the naval model shop in the National Capital; and his establishment in Manhattan is probably the largest and best equipped plant of its kind in the United States.

As the illustrations accompanying this article indicate, Mr. Boucher makes more than marine models, but the purpose of all of these creations is to supply the element of the third dimension and to permit both the technical and the non-technical observer to visualize the relations of things and to get a sense of proportion. The habit is strong with all of us to query, "How does the thing work?" It is the survival of our earlier days when we wanted to pry into a watch or clock to see the wheels go round. The picture of the longitudinal section of the army transport "General Sherman" shows that it is possible to get speedily a comprehensive grasp of the whole interior of that vessel and to see to what purpose the various compartments and sections are devoted. An examination of the model, itself, gives a still greater wealth of structural data—details that reveal just how much thought must be given to the planning of a ship so that every department may serve its end to the best advantage and that all available space may be put to good account.

But we cannot flatter ourselves that we have been the pioneers in helping the rightfully inquisitive to learn through such mediums about the internal get-up of full-sized vessels. As a matter of fact, we have not carried this educational work anything like as far as wisdom would suggest. Whether we like it or not, the Germans have led by a long way in this realm of enlightenment. Sixteen years ago, our naval attaché at Berlin informed us that all of the Kaiser's warships were furnished with skeleton models for the instruction of their personnels. The German Admiralty recognized that it was very desirable that everybody aboard a fighting ship should be familiar with every phase of its construction and equipment. The Teutons did this because they were aware that drawings and blueprints are not readily understood by the sailors and that even the officers frequently found it hard to grasp their meaning.

Further, the interior of a ship is a complex network of compartment and lesser subdivisions, and many of these are isolated from one another so that a man in one space cannot step readily through a door into a neighboring one and thus



A MODEL OF THE TROY LOCKS OF THE NEW YORK STATE BARGE CANAL

get an understanding of their degree of association. He must travel up a ladder, through a hatch, and possibly around a number of obstructions before he can make his way down into a near-by compartment—confusing the while his sense of relationship. The skeleton model, on the other hand, which permits deck after deck to be lifted off and allows the observer to see successively just how a craft is fashioned and is interdependent, makes it feasible for all but the utterly stupid soon to master every essential detail of his ship. The Germans did not hesitate to promote this knowledge by supplying models costing anywhere from $500 to $2,500.00.

The same naval attaché was later ordered to the Asiatic Station to command the U. S. Monitor Monterey; and it was not long before it was impressed upon him that it was very desirable for him to know his ship in the fullest sense of the term—to be familiar with the positions of all watertight compartments, the arrangement of the double bottom, and the leads of a multiplicity of pipes having to do with safeguarding against disastrous leaks, the proper ventilation of out-of-the-way areas, and the distribution of motive steam—not to mention that network of nerves in the form of electric wires and conductors. For $110 in gold he got three Chinese carpenters to build him a beautiful and exact demountable skeleton model of the Monterey; the ingenious Orientals using the simplest of materials to fashion the miniature—cunningly requisitioning macaroni to serve for piping and valves, and

coloring each of these to indicate the particular system to which it belonged.

At the U. S. Naval Academy, models of vessels have played their part for years in the education of our midshipmen, and by them our embryo admirals have been able to comprehend technical features and operative procedures which otherwise might have puzzled them sorely. The array of full models and the still more numerous half models there tell their own story of how our naval constructors in the decades gone have felt their way before risking the nation's funds in the buildiig of the actual craft. Finally, the so-called handsome display models generally built by the Bureau of Construction and Repair of the Navy Department have proved of the utmost value in bringing vividly home to our inland citizenry an understanding of our fighting fleet—thus serving to promote a necessary interest in our seagoing defenses and to stimulate enlistment.

Big steamship companies are fully alive to the psychological appeal of a miniature replica of their passenger craft, and all of them know that the thousands of dollars expended in this way are richly repaid in patronage. Foreign lines have been especially shrewd in thus reaching first our imagination and next our pocketbooks. A third reason for ship models is a sentimental one; and this is apt to grip strongly the yacht owner. It yields him no end of quiet delight, when the days of cruising are halted and his craft is hibernating in some snug harbor, to look upon the little model and bring to mind vividly every detail of weeks and months of enjoyment and to arouse again the fascination of measuring strength with fickle winds and treacherous seas. A picture would only give a small part of this satisfaction because of the flatness, the two dimensional character of the mediums of expression. The model, on the other hand, he can scan from all angles and revel in an ever-changing point of view.

In building the "block" of a model seasoned white pine of the finest sort is used. The block is formed up of a series of planks so wonderfully smoothed that their surfaces come together throughout, and, under moderate pressure, exclude the air. As a result, the thinnest film of glue is essential to establish a vacuum and to bind the successive layers or lifts into a single mass. Before they are united in this fashion, the contours are traced in pencil upon the planks, and frequently the lifts are sawed approximately to shape. Next, the woodworker cuts away the pine carefully until the penciled contour at each waterline is brought to light, and then he clears away the material between neighboring water lines, checking up the body form from time to time by little templates of the different curves at prescribed positions, usually from keel to deck upon definite frames. When the lines are true in every particular, the skin surface of the hull is smoothed to a nicety by sandpapering.

While the woodworkers are busy at their respective tasks, the metal-workers are engaged in fashioning with amazing fidelity to detail a varied array of fittings and equipment. With infinite cunning they call into being mooring bits, hawse pipes, davits, boat cranes, windlasses, winches, searchlights, guns, ventilator cowls, smokestacks, anchor chains, etc. In many respects their products call for manual skill greater than that of the jeweler. A few of these features can be cast, but many of them have to be wrought by lathe or patiently created by tool, blowpipe, and the smallest of soldering irons. For the most part brass is the basic metal; and if the full-sized replica is of brass, then the fitting is polished and plated with gold to hide the traces of solder. Nickel plating coats the fittings that would be of polished steel or nickel in the full-sized craft; and tinning is the model's substitute for galvanized-iron equipment.

But before the metal features are placed upon the model, the hull, superstructure, deck houses, etc., must be colored in perfect accord with their corresponding portion of the full-sized vessel. Some idea of the painstaking work entailed can be gathered from the fact that the hull may receive anywhere from five to eight coats of paint, and each coat is rubbed down before the next is applied. Ultimately the miniature is varnished, and this, too, is rubbed and rubbed until it is impossible to detect the slightest trace of brush stroke. With the body of the wee craft ready for its fittings, then these are put in place with precision, and the care exercised must accord with a scale that crowds into only a quarter of an inch the equivalent of twelve inches. A few hairbreadths of error might spoil the interrelation of a number of features. Finally, masts are stepped, stays, signal yards, and running rigging are set or rove. Tiny boats are fixed in their chocks or hung at the davits—the blocks and falls faithful in every particular. No wonder, some models may be composed of 10,000 or more pieces, for neither Mr. Boucher nor a knowing critic would be satisfied if anything were missing or if any fitting seemed lacking an essential working detail.

The layman should not be astonished to learn that it takes the joint efforts of a considerable force of expert craftsmen and weeks and months of continuous work to produce a complete display model. The determining factors are the size of the real vessel and the variety and number of her characteristics and equipment. The so-called miniature may be but a few inches long or, in the case of a dreadnaught or ocean greyhound, may measure from bow to stern from 12 to 20 feet. The cost of these beautiful productions runs from $300 up to $12,000 or more.

DEMONSTRATION COAL MINES.

By J. J. RUTLEDGE,[1] McAlester, Okla.

THE United States Bureau of Mines established at Bruceton, Pa., in 1909, an experimental mine for the purpose of testing the means of preventing and limiting mine explosions. During the last ten years, numerous explosions have been caused to originate in this mine for investigative purposes and the rate of propagation of the explosion wave, the pressure developed per unit of area by the explosion, and the general results of the explosions have been carefully recorded and studied. Means of preventing mine explosions or of limiting them to the areas in which they originate have been developed. A great deal of valuable information has been derived from the work in this mine and much more useful and valuable information will be obtained in the future. The writer would plead, not for the opening of experimental mines in all the important coal-producing fields in the United States, but for the opening of demonstration mines, or mines in which experiments could be made with the various details of coal mining.

Owing to competition in the same markets, small capitalization, or low profits, it may be an utter impossibility for any one company to try a new method of mining. Labor conditions may prevent the trial of a new method of working. It may be impossible or inadvisable to disturb existing working conditions for fear of causing trouble among the miners through real or fancied changes in the scale of wages.

If a certain method or plan of working had been shown to be the safest and most efficient, public opinion would force coal operators to adopt the new methods of working, if they did not do so voluntarily, and public opinion would also furnish moral support to the operators in overcoming any opposition that the miner and other employees might manifest toward the installation of the new and better method.

If a new method was found to be safer and more economical than the one in use, the authority of the state could be invoked to support any operator who desired to adopt it. Very few coal-mine operators would dare run counter to public opinion, even were they to ignore the financial benefits to be derived from the adoption of the new plan. Compensation insurance companies, through their mine inspectors, would give credit to those mines that adopted the new methods with the result that their liability insurance would be materially reduced in cost.

[1] Mining Engineer, U. S. Bureau of Mines.

EXAMPLES OF SPRAY PAINTING, SHOWING A WIDE VARIETY OF APPLICATIONS

Spray Painting*

A Study of the Practicability of Blowing Paint on Various Surfaces

By H. A. Gardner

THE war placed such great demands upon the painting industry that it was found necessary to utilize every means to accomplish the huge painting program that developed. The shortage of men capable of wielding brushes soon became apparent and the great speed demanded in production developed as a vital factor. As a result, the steel hulls of many vessels, the rough siding of many temporary buildings, and the surfaces of thousands of guns, tractors, and other military equipment were coated by the spray machine. Because of the speed obtained through the use of this device for preserving or camouflaging materials of warfare, attempts have been made to develop it for peace time painting purposes. To many observers the question has come as to whether the machine is of sufficient practical value to merit a permanent place in the art of painting and whether it will to any extent replace the old-time hand paint brush.

Some observers have stated that hand-brush manufacturers cannot produce sufficient brushes to apply the paint for which such great demands exist. While the apparent shortage of bristles might to some extent be held responsible for such a situation, it has been suggested that even though bristles were as plentiful as at any time previous to the war, it would be difficult for manufacturers to produce an over-abundance of brushes for coming needs, and that the brush industry could not therefore be injured through the development of the spray-painting machine.

Similarly it has been advanced that the occupation of the journeyman painter could not in any way be injured by the adoption of spray painting for certain special classes of work, since it is often impossible to obtain sufficient labor to apply the paint for which such enormously increased demands exist. Furthermore, it has been claimed that unless some means is provided for at least partially relieving the situation, millions of dollars of loss may result from the surface decay that will take place on unpainted structures. It is undoubtedly true that painting was neglected to such an extent during the war period that immediate action must now be taken to preserve the property that will otherwise be damaged if longer left unpainted. This means that during coming years an even greater demand will develop for paint and varnish products. Any legitimate and satisfactory means for the application of these products should therefore be welcomed not only by the master painter but by the journeyman painter and the public. The use, for instance, of the spray machine (if found practicable) will not only be of service to the property owner but will actually stimulate the employment of and demand for painting labor. To make this more clear, it has been suggested that a comparison of the situation be drawn with the effect of the sewing machine upon the tailoring industry. The journeyman tailor undoubtedly at first loked askance at the development of such a machine. It was soon found, however, that this machine created an almost entirely new industry in the production of ready-made clothing. The availability of these products at once effected a great demand and increased usage. As a result, thousands of operators were required where but hundreds were employed before.

It is believed, therefore, that any device that creates new business in new fields is to be given the hearty support of all, if found to be of a practical nature. Whether or not the machine will prove useful will depend upon the results obtained by the painter during the coming period of great activity in his trade. He may, for instance, find it well suited for certain classes of work and unsatisfactory for other kinds.

Some observations made by the writer on tests with the spray painting machine may be of interest to the members of this Association in judging of its possible usefulness in their work. The tests were made on large surfaces with both hand brushes and spray machines. After a sufficient period of exposure, data will be available as to the comparative durability of each type of work.

SPRAY PAINT TESTS AT WASHINGTON.

The tests referred to were made in Wahsington on govgernment buildings by one of the prominent members of this Association. The machine used in the experiments consisted of a 4-H. P. motor, a large air tank, and a 5-gallon paint tank. It required 220-volt direct current. For the roof work the paint tank was hoisted to the roof and two hose leaders were carried from the air tank located on the ground. Two operators could work at the same time with the paint tank which was fitted with two spray guns.

*Paper presented at the convention of the International Association of Master House Painters and Decorators of the United States and Canada, New York City, February 12, 1920. Copyright 1920 by H. A. Gardner.

For the exterior work an experienced spray brush operator started the work on one side of the building, and two journeymen with 4½-inch hand brushes started the work on the other side, which was a duplicate in size, shape and construction of the side selected for the spray test. After the work had been started a journeyman painter entirely unfamiliar with the use of the spray gun was shown how to operate it. He completed the tests, including the walls and roof area. It was apparent that a very short period of time was required to instruct a man to use a spray gun. The tests were of good size and included on the side walls an area of over 8,000 feet and on the roof an area of nearly 9,000 feet.

The paint used for the exterior wall work was a lead paint tinted with ochre, weighing 17.6 lbs. per gallon for the first coat and 20 lbs. per gallon for the second coat. Both paints were easily handled by the spray gun. The paint used on the roof was an oxide of iron paint weighing about 14 lbs. per gallon. The paint used for the interior work was a modern sanitary flat wall paint of the lithopone type, weighing 14 lbs. per gallon. It was apparent that the spray gun would successfully handle paint of practically any weight per gallon.

In doing the first coat on the exterior brick walls, all cornices and trim were cut in with the spray on the side of the building where the spray test was made. On the second coat, however, the cornices were cut in by hand with a brush, in order to assure a neat job. The time of the brush work was counted in as spray-gun time.

It has previously been assumed that the average journeyman painter, working on wall surfaces and using a hand paint-brush would do about 200 square feet an hour, or about 250 square feet an hour on roof work. In these tests however a much greater speed was attained in the hand-brush work. It is assumed that this was due to the great interest of the painters in the test.

Observation of the completed work showed that practically no difference in the appearance of the spray and the hand-brush work existed, with the exception that the spray work was slightly more opaque. The painters in applying the paint by hand with 4½-inch brushes used drop cloths at the base of their work, whereas no drop cloths were used by the spray workmen. There was apparently little paint falling to the ground, the only loss being in the form of a fine mist. On a damp day this mist, of course, would be greatly intensified due to the presence of the volatile constituents of the thinner. This mist would lead an observer to believe that considerable paint was being lost, whereas, as a matter of fact, only a very little quantity of paint was being dissipated as mist. The mist was of a somewhat colloidal character and the effect was largely optical. On the interior work, however, a noticeable difference was shown. The mist in the room where the paint was being applied by spray guns was very noticeable. Drop cloths were required on the floors in order to prevent staining. Painters employed for continuous periods on interior spray work might to advantage wear a simple form of respirator. The roof work was, of course, subjected to strong currents of air, but there was apparently no very large loss of paint. It was observed, however, that the overalls of the painters using the spray guns become somewhat more soiled than where hand-brush work was being done.

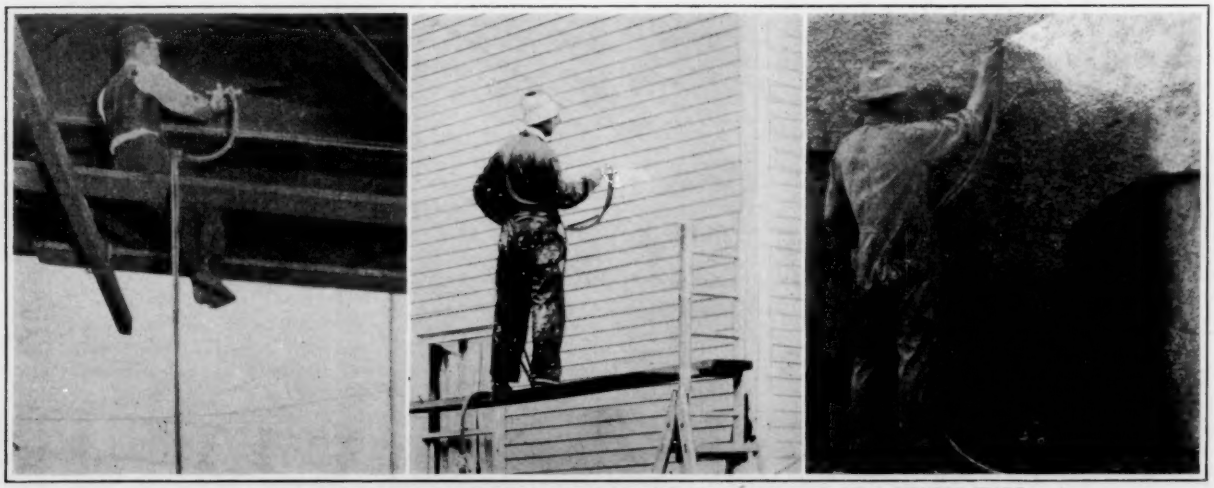
On the interior tests, one room was done by two painters with hand brushes and two rooms with the spray gun by one operator. The rooms faced a courtyard in which the machine was placed with hose leaders running up to the work. The ceilings of the rooms were arched, four arches meeting in the centre of each. This made the painting rather difficult by hand but very much easier for spray work. The side walls had four projecting columns, one at each corner, and between the tops of these columns and the arched ceilings there was a heavy scroll cornice. Each room also had a fireplace and chimney breast and large recessed combination windows. The hand work was somewhat marred by streaks and the covering was poor. The spray work was greatly superior. A very much heavier coating of paint was apparently applied. It was necessary to put on two coats of paint by the hand brush in some instances in order to get satisfactory covering.

Information gathered from some of the journeymen painters indicate that they are not averse to the use of the spray gun after they become acquainted with it. In fact, the painters showed less fatigue at night than when using hand brushes. Some were therefore enthusiastic about its use.

Dr. Gardner's paper was accompanied by tables of tests which are here omitted because of limitations of space. These tables show that on previously painted metal roof spraying requires approximately 10 *per cent more paint than brushing, while brushing requires approximately* 200 *per cent more labor than spraying.*

On previously painted brick walls and stone cornices spraying required approximately seven per cent more paint than brushing, while brushing required approximately 109 *per cent more labor than spraying.*

On combined ceilings and walls of plaster spraying required approximately 40 *per cent more paint than brushing but gave quite good hiding in one coat, while brushing required approximately* 160 *per cent more labor than spraying and gave poor hiding in one coat.*—EDITOR.



SPRAYING PAINT ON STEEL GIRDERS, ON A FRAME BUILDING AND ON A STUCCO WALL

The Menace of Vibration

Some Interesting Observations on Troubles in Turbo-Generators

By E. V. Amy, E. E.

THE recent rapid development of large capacity steam turbine-driven electric power-generating units has made the subject of vibration of great importance and worthy of more serious attention and consideration, for both the designer and the operator. Vibration has become a factor having considerable influence on the present limits of speed and capacity of single shaft steam turbines. The exact nature of the vibration set up in the wheels and blading of such turbines is at present one of the engineer's most difficult problems. Very little is known of the theoretical nature of this form of vibration although common to all steam turbines. It remains a problem requiring further investigation and research on the part of the engineer and designer.

It is not the purpose of the following article to enter into a theoretical discussion on the nature of this type of vibration, but, on the other hand an attempt is made to outline the many other causes of vibration in large turbo-generators of present-day design, and to mention some of the troubles and dangers which often arise when vibration in such machines becomes abnormal and is allowed to persist unremedied.

In the reciprocating engine with its low speed any lost motion or misalinement makes itself known as a knock or pound, while in the case of the turbine with its high speed and very delicate balancing the slightest knock or pound may become very serious vibration and cause considerable damage to the machine. With high-speed machines like turbines it is vitally essential that all revolving parts be accurately balanced, and that this condition of balance be maintained at all times during the operation of the machine. The proper balancing of machines is in fact a science in itself.

For the proper balancing of the rotors of steam turbines and generators, two balances are required to ensure a steady running condition, these are the static and the dynamic balances. The static balance is obtained by revolving the rotor by hand on a pair of knife edges or balancing stools. It is revolved and allowed to come to rest, the point at the bottom being the heavy part. Temporary weights are fixed to the rotor opposite this part and the rotor again revolved and weights added until it will stand or come to rest in any position. The rotors are balanced dynamically with as much care as possible on a special test floor by the manufacturer. The details of the apparatus employed by the various turbine manufacturers for dynamically balancing their machines varies of course in design, but in general the method is to rotate the body at operating speed by some external source of power, with the shaft and bearings spring held, so as to allow a slight oscillation of the shaft in one plane to be produced by any out-of-balance condition of the rotor. The shaft is chalked at each extremity and by gradually advancing a fine metal stylus until it lightly touches the revolving shaft at the high spots of the oscillation, a mark is thus made in the chalking on the shaft indicating the relative places where the balance should be changed. The weight is altered and the test repeated until the best balance is obtained for that end of the shaft, so that there is no oscillation. The other end is then balanced in the same manner and the dynamic balance of the rotor and shaft as a whole thus completed with respect to the journals in which the shaft is held.

Few large rotors are actually in a state of perfect balance owing to the difficulty in obtaining an absolutely accurate dynamic balance. Furthermore a physically perfect balance for all speeds is not attainable. The greater the speed at which the rotor is to be operated the more careful and accurate must be the dynamic balancing.

The intensity of the vibrational force due to out-of-balance of a rotor will in magnitude be proportional to the square of the speed and the number of times this force is applied per minute will vary directly with the speed of the machine. Therefore if we consider only the fatigue stress the harmful effect of a given amount of lack of balance will vary as the third power of the speed of rotation of the machine.

A dynamic balance considered perfectly good for a certain environment may prove to be a bad out-of-balance in other surroundings. A large capacity machine that runs quite smoothly on a massive foundation of concrete may set up dangerous vibration and noise when mounted on I-beams or set up on a steel structure. Commercial requirements call for the designing of standard types of machines, made in quantities to meet the demands of a general market. In many cases the refinement of balance depends upon the average place and conditions of use, as far as can reasonably be predetermined. However should such a machine happen to be installed under adverse conditions which resonate with any little out-of-balance which the machine may have, it is immediately blamed for the trouble and in many cases condemned; whereas it would have run perfectly well if a little more consideration had been given in slightly modifying the foundation.

For all bodies mounted on a shaft and rotated at high speeds about fixed axes there is a certain period at which vibration will become excessive, this is called the critical point of speed and is believed to be caused by a change in the axis of rotation due to the deflection or bending of the shaft which causes the rotor to revolve about a new axis termed the axis of rotation or deflection and which alters the center of gravity of the body and causes vibration. This may not occur at the highest speed, as sometimes this vibration decreases as the speed is increased.

Vibration in machines like steam turbo-driven generators may be due to causes internal or external to the machine, or both, the result being cumulative or otherwise. In general, however, the most common causes of vibration are unbalanced rotors, bent or poorly alined shafts, loose parts, improper foundations and fastenings, excessive speed, excessive and fluctuating loads, and vibration of the structure housing of the machine having its periodicity of vibration superposed upon that of the machine.

The most serious and dangerous kind of vibration in turbines, although not frequently encountered in well designed machines, is that due to revolving parts improperly coming in contact with the stationary parts; this applies especially to the buckets. Such trouble will lead to the greatest damage if not promptly detected and properly dealt with. A vital maxim in turbine practice is to avoid any internal rubbing.

One of the greatest troubles experienced in maintaining good balance of Turbo-generators is due to the shifting of the conductors. The slightest shifting of these conductors on the rotor of a large generator is likely to throw the machine considerably out of balance. This often happens after the generator has been in operation for some time; as the insulation dries and becomes compressed by centrifugal force on the conductor it allows the conductor to loosen a little in the rotor slot. Once these conductors become at all loose they may shift with load changes, causing deterioration of the insulation and failure under normal potential.

Vibration may be caused in a machine by allowing too much bearing clearance. Such vibration is more or less of a local nature, and while it may be felt throughout the entire machine it is usually more intense at the bearing or bearings which are loose. It is also more noticeable when the machine is running with light load than with full load, or in the case

of alternators when the field current is off, becoming less as the field magnetism grows stronger or the load becomes greater, holding the roter in a more fixed position. In some cases this vibration can be reduced by feeding more oil to the bearings.

The proper lubrication of large steam Turbo units is an important problem upon which the smooth operation and future life of the machine are greatly dependent. If the oil film under a bearing should break down due to a poor supply, low pressure, or other failure of the lubrication system, the bearing besides becoming heated would be let down with the possibility of causing serious damage to the blading of the turbine. Unequal wear on the bearings or shaft would in turn throw the machine out of alinement.

A serious trouble sometimes encountered in large Turbo-generators as a result of excessive vibration of the machine is that the emergency steam valve accidentally closes, shifting the generator's load to other machines. This may prove a very grave matter in power stations where the load is 30,000 kva. or more. A leaky throttle has often caused a turbine to vibrate when first started. Allowing steam to enter when the turbine is standing still heats the rotor casing unequally which causes the rotor to run out of true and vibrate when started. For this reason it is the general custom to rotate all large steam turbines slowly while warming up.

The failure or improper adjustment of labyrinth packing has in the past few years caused considerable trouble with many of the larger turbo-generators, often necessitating their shutting down when most needed in operation. The function of labyrinth packing is to reduce leakage losses. It is used in some form in all types of turbines. The essential idea on which the packing is based is not so much the causing of the steam to take a tortuous path as to wire-draw it at a great number of points. In most single flow turbines it forms the packing on the periphery of the balance piston which is used to counterbalance the thrust of the steam on the active turbine elements. In nearly all other types it is used in the steam glands to prevent the flow of steam through the opening in the turbine casing through which the shaft passes. Theoretically it should be durable enough to withstand the action of the steam but not strong enough to impose injurious local heating in case of rubbing or surface contact. In the past it was the practice of many manufacturers to make this material too strong and considerable trouble was caused by heating due to contact which resulted in distortion of the holding rings. Nowadays this packing is made of different design and better material which will not cause injury to adjacent parts in case of surface contact.

In general it might be said that there are many degrees and types of vibration in large steam turbine-driven units, causing as many effects, some obvious and others not so apparent. But in nearly all cases vibration sounds its own warning and therefore requires the constant vigilance of the operator and attendants. The operator and the attendant must be always on the alert and thoroughly familiar with all normal running conditions as to sound and vibration, so that he can promptly detect anything unusual in the operation of a particular machine and quickly diagnose the trouble, if any, and to report it or apply the proper remedy at once, before it becomes of such a nature as to cause damage to or wreck the machine.

MANGANESE.

IN a report to the Bureau of Mine, W. C. Phalen describes several uses for manganese other than steel making. Estimates of the quantity of manganese ore used in the industries other than metallurgical vary from twenty-five to fifty thousand tons yearly. Most of the ore is a high grade of pyrolusite, commanding a much higher price than metallurgical ore, and is usually described as "chemical manganese ore."

The principal non-metallurgical use of manganese is as an oxidizing agent in the manufacture of dry cells; as a decolorizer in certain kinds of glass where it combines with the iron present in the sand to form a colorless or neutral shade of iron salt; and as a drier in oils, paints, and varnishes. A small quantity enters into the manufacture of manganese chemicals. In text-books the use of manganese as a raw material for the production of chlorine through the reaction of manganese dioxide with hydrochloric acid is given, but this is no longer a commercial operation. No doubt chlorine, which is produced when manganese chloride is prepared, may be used, but today chlorine gas is an abundant by-product in the electrolysis of brine in the manufacture of sodium hydroxide and potassium hydroxide.

It is interesting to note the part played by manganese dioxide in the dry cell which is ordinarily, but incorrectly, called a dry battery. A modern American dry cell of the usual type is a portable modification of the "disque Leclanché" cell invented by Leclanché about 1868. The negative pole consists of a cylindrical zinc can of which about seventy-five million are now made annually in the United States in the number six size alone. The can also serves the purpose of a container and the popular size, number ix, is about two and one-half inches in diameter by six inches high. The inner surface of the zinc is lined with a special grade of absorbent paper, acting as a reservoir for the electrolyte and as a diaphragm between the zinc and the positive pole. The depolarizing mass, called the mix, is tightly tamped into the can around a centrally located carbon electrode to within about one inch of the top. This mix is ground carbon, usually calcined petroleum coke, and graphite, manganese dioxide ore, and the electrolyte. The mix, together with the carbon electrode, forms the positive pole and after it has been tamped, the paper is turned down over it, sand or sawdust is poured in to a depth of about one-half inch, and the cell is sealed with a hot pitch composition. The layer of sand provides an expansion chamber for the electrolyte, ammonium chloride, and the excess gas, and also a dry bed for the hot pitch.

Comparatively little of the zinc is used up during the service life of the cell and one of the problems of the dry cell manufacturer is to so construct the cell as to obtain uniform corrosion. The paper must be porous enough to allow the electrolyte to diffuse through it but still retain the smallest particles of carbon and manganese.

Much work has been done on methods for recovering the unexpended manganese dioxide from these dry cells and at least one laboratory has reported substantial progress.

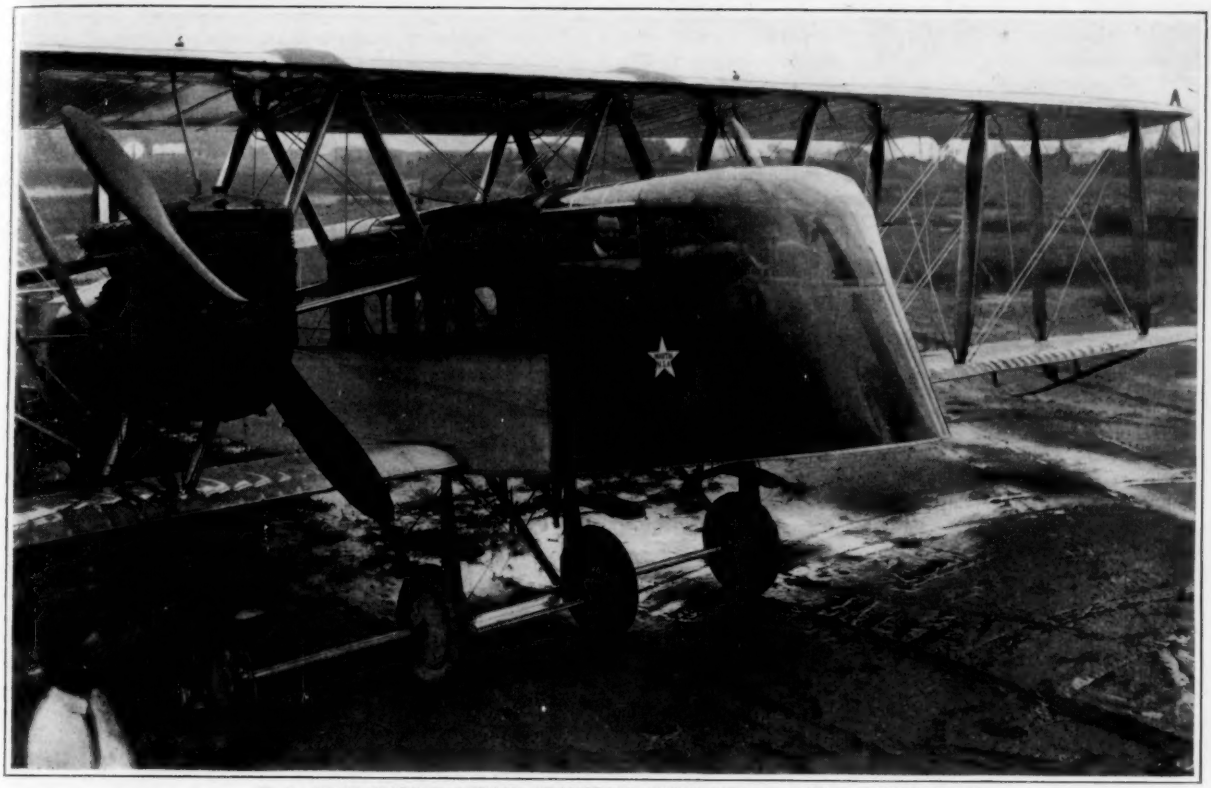
OIL IN ENGLAND.

THE acute need for fuel in Great Britain has excited great interest in the possibility of discovering deposits of petroleum. Much prospecting has been done, especially in Derbyshire. Whatever success may finally attend those investigations, there has recently been discovered a source of fuel oil which, if reports are true, promise to become of first importance and of immense value. This is the oil shale deposit of Norfolk.

In 1907 Dr. Forbes-Leslie began a systematic investigation of these deposits, which has resulted in the finding of large quantities of shale and the formation of a company for their development. At first little interest was taken in these shales as their sulphur content was too high to permit their use as a source of fuel oil. Further investigation has shown that this is true only of the upper seam of shale.

These Norfolk shales are entirely different, geologically, from the well known Scotch shales. They consist of a clay saturated with liquid petroleum from some source below. A form of ozokerite occurs with them. When retorted they yield 40 to 50 gallons per ton of an oil practically free from sulphur and rich in motor spirit and paraffin.

The quantity of shale available is practically inexhaustible, the amount being estimated as 2,000,000,000 tons. This amount is sufficient to supply England's present oil needs, as indicated by her imports, for over a century. The seams lie between the surface and a depth of 400 feet, average 150 feet in thickness and are remarkably uniform in thickness and yield.



U. S. ARMY MARTIN AERIAL TRANSPORT EQUIPPED TO CARRY PASSENGERS

The Airplane as a Commercial Possibility*

Changes Necessary in Present Equipment, and Future Developments

By D. W. Douglas

THE cessation of the great war has left the airplane machines and engines of the highest quality in the world. industry in America well equipped to design and produce It has, however, left it in poor shape for existence, for few of the airplanes developed for military purposes hold much promise of successful adaptation to peace-time commercial uses. Future military business of any magnitude is problematical. That the war has advanced the science of aeronautics and in a way that will help to solve even the commercial problems is true; and it has given the industry opportunities for the betterment of its products that would not have come to it in double the period of time in peace. That commercial use must be made of airplanes to support even a part of the capital and interests involved in the business at present, seems necessary.

Many people argue that the Government cannot afford to allow this great and new industry to languish because of lack of business, but must foster and further it by subsidy or continued military orders. That such a course would be welcome at this critical period is undeniable, but total dependence of existence on this problematic possibility would be fatal. Governments are sometimes slow in acting in a sufficiently decisive manner on such problems, as is witnessed by the disappearance of our merchant marine in the latter part of the nineteenth century. Furthermore, government subsidy does not always appear healthy for the sound development of commercial projects. Of the early transcontinental railroads, those that received the least or none of the support accorded by the Government remained the most financially sound.

The problem before us today is: What practical use can be made of airplanes, what volume of business can we expect to secure with them, what changes of or developments from present military machines will be necessary to give us an efficient commercial machine, and what does the future hold for this new means of transportation? Let us inquire into the probable fields that the commercial airplane can hope to enter, and, either competing successfully with other means of transportation or supplying the lack of such transportation, become a recognized factor in the development of commerce and the furtherance of social and economic intercourse throughout the world.

PASSENGER TRANSPORTATION.

Since speed is the most outstanding present-day advantage of the airplane, I rank passenger carrying first in importance. Many of our daily business and personal affairs can be successfully conducted only by a personal meeting or inspection. Correspondence, telephony and telegraphy cannot supply the complete satisfaction of actual personal contact. Where any great distance separates the subject and his objective, present-day express train service often proves too slow.

Time wasted in travel means money lost, suffering endured or pleasure sacrificed. Granted safety comparable with that of our present means of travel, in point of fatalities per miles traveled, and that I trust will be demonstrated soon, are there not many instances in the life of any person when he

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would gladly pay twice the railroad fare to reduce his travel time to one-half or one-third? Is it not conceivable, then, that having once found that this saving is worth something to him at a critical time, he will avail of it again for some less important reason? Soon he will find, if he be a man of large and pressing affairs, that he is remolding his schedules on the basis of this new time-annihilating service. The first problem, then, seems to be to win the confidence of the public, to institute a successful passenger transportation line between two great cities such as New York and Cleveland.

Aeronautical people all feel confident that with the lessons learned from military experience and with new safeguards thrown around the airplane in its operation and maintenance, such a service can be safely embarked on with our present-day knowledge and material. This must be proved by actual performance rather than by statement, and so the airplane builders or those with the necessary knowledge, enthusiasm, and capital who will come forth as commercial operators must take the risk. In one way or another they must actually carry passengers. They must carry them on schedule, comfortably and without mishap, and for a reasonable period of time. Experimental human material is needed, then, in addition to the experimental carriers of it. To my way of thinking, and from observation of and conversation with many people, there is plenty of such material in the adventurous, the curious and those whose extremity may be so great as to warrant the chance they are sure to believe they are taking at the time.

Granted, then, that sufficient patronage of a not too serious order can be counted on for starting a passenger-carrying airplane line of small size, what form will this first venture assume? Three methods of attack can be followed and are being followed at this time. They are:

(1) Scheduled regular service
(2) Special taxi service
(3) Tourist service

Of the three the first seems to hold the most promise of giving us our first real data on costs, maintenance and traffic. While it appears offhand to involve the risking of more capital than the last two, it need not preponderate greatly in this respect and certainly will offer a more accurate count of the public pulse than the other methods. By scheduled service I mean, of course, the operation of one or more machines flying between two or more points on a time schedule properly based on the safe speed of the plane, the altitude flown and the head winds likely to be encountered. No such service has as yet been actually started either here or abroad.

In England various airplane firms have ready machines carrying from 10 to 40 passengers; the French Farman carrying 12 persons and the big Caudron Company are only waiting for military questions to be settled before opening up regular service between London and Paris and other European cities. England has big projects along these lines throughout her colonial possessions and seems imbued with the determination to realize them. In Italy Caproni is building larger passenger planes than anyone, which it is said will be operated from the northern to the southern part of that country and even across the Mediterranean to the African possessions.

Other enthusiasts believe that the safest course to pursue in breaking into the transportation of passengers is through the use of the taxi system. To illustrate this I may state that the Curtiss Aeroplane Company intends to maintain a fleet of fast machines at a flying field near New York City, always in readiness with expert pilots in attendance to take anyone with the necessary confidence and money to any part of the United States. Our Air Service has for some time been using planes for a similar service. In Washington several machines and some of the best pilots in the service are ready at any time to carry high officers or officials on a joy ride or a quick official trip to other cities within 400 miles.

At Atlantic City companies are planning to handle the tourist trade. That they will meet with success in joyriding pleasure seekers next summer seems dependent only on their intelligent use of the best materials and personnel.

AIRPLANES AS MAIL CARRIERS.

Passing to the second commercial use of airplanes, mail carrying, we enter a field where the element of danger is not of so much importance. It is not to be neglected any more than in passenger carrying, but the possibility of crashes do not limit the initial business.

Under the heading of mail carrying I will group several functions:

(1) Regular mail transportation
  (*a*) By the government
  (*b*) For the government
(2) Fast dispatch service
(3) Financial service

In regard to the carrying of mail by plane, everyone is acquainted with the fact that the Postoffice Department has had a service in operation for the past year between New York City and Washington. It has operated this with its own personnel and material, and made a remarkable record on this run for efficient and continuous service. The amount of mail carried has, of course, been small as the service is only a beginning. About 160 pounds of mail is carried every day from each city, the pilots flying in all sorts of hazardous weather. Rain and storms fail to frighten them, and the instances of failures have been very few. The Chicago-New York City route was, as you know, unsuccessful in the first trials, but this was due mainly to faulty machines for this long haul, ignorance on the part of the pilots of the country traversed and a rather hasty start without proper organization and equipment. Next spring this run will again be instituted, and judging from the preparations being made and the machines that will then be available it should be as successful as the aerial postal service operating between New York City and Washington.

Whether the Postoffice Department will contract with airplane transportation companies for carrying mail in other localities will depend to a great extent, I judge, on the record of performance actually accomplished in operating their lines for some other uses. It is not inconceivable that a company which had been regularly and successfully carrying passengers on a certain route would be able to secure contracts to carry some government mail along with the regular load.

Under the second function of mail-carrying types of planes comes independent carriage of special commercial dispatches. A service could be maintained with fast planes, flying both night and day, that would bid fair to outrival the night telegram service between cities over 300 miles apart. It would be as quick at probably lower charges and have the great advantage of accurate transmittal and the possibility of conveying information other than that written.

Machines engaged in this work could also handle the third class of mail-machine operation. Where the saving of a few hours in the time of transmittal of a draft on a bank in one town, to be deposited in the other, may mean the saving of a day's interest, fast airplane service would certainly be an advantage.

GENERAL EXPRESS TRANSPORTATION.

If we now take up the third peace-time use of the heavier-than-air machine, general express transportation, we enter a field which at first glance does not appear to offer much encouragement to the airplane as a carrier. Express and fast freight service throughout developed parts of the world is generally good and, of course, much cheaper than similar service by wing. On the other hand, as in carrying passengers, the future promises a class of people to whom the greater speed is a worthy consideration; so in the transportation of merchandise we will find classes of goods which can bear the extra cost of moving in exchange for the time saved. This may prove particularly true in conveying goods from small

towns with indifferent rail service to the larger centers. Among the articles which can bear the extra tariff are:

(1) Perishable goods
(2) Replacement parts for damaged machinery
(3) Medical and surgical materials
(4) Motion picture films
(5) Newspapers
(6) Luxury articles

Taking up the question of perishable goods that can bear the expense of airplane travel, we may list such things as high-grade certified infants' milk, rare and out of season fruits, vegetables and flowers. The milk for New York City is supplied largely from upstate dairies not having the fastest of rail service. With a preliminary cooling at the dairy this milk could be carried quickly and deposited still cold in the city. Where the breakage of intricate machine parts threatens the tying up of a plant, the aerial express line should find an opportunity to be of value. Shortages in factories working on a production basis that could ill afford an interruption could be made up from stock in a distant town in the minimum time possible through the air. Occasions arise in epidemics or catastrophes where the shortage of medical and surgical materials, personnel and food becomes serious. With airplanes such supplies could be rushed in the fastest way. Motion picture films could not only be distributed in the shortest time by airplanes, and thus cut down exchange and idle time, but the service would add to the advertising campaign of film companies. News grows stale quickly and small-town papers do not always satisfy the residents of such communities. The faster distribution would increase the out-of-town sales of the daily papers of our large cities and widen the range of their circulation. Articles of luxury which bring high prices in proportion to their weight could in many cases have quicker distribution profitably. Advertisement would enter here to a greater extent than in any other class of service possible. Confectioners and florists in the large cities, enjoying a wide reputation and a high-class trade, could broaden the field of their patronage considerably.

AERIAL TRANSPORTATION OF MINERAL ORES.

Mineral ore, while appearing to be a difficult cargo for seemingly flimsy aircraft to carry, is, in certain localities and in certain grades of ore, a practical load for airplanes. Where mines producing rich ore are located in inaccessible country not tapped by railroads or highways, barring exceptions where the character of the terrain precludes the possibility of landing fields or where altitudes are excessive, an aerial transportation system could be installed without the necessity for heavy investments in roadbeds and grading and could be operated at costs that would not be excessive. If the mine be a small one, removed from the possibility of surface service, the airplane can take out the ore and when the workings are barren leave no great amount of useless investment on the location. In addition to carrying the ore out, labor, equipment and supplies can be brought back on the return trip. Where speed in the operation of a newly found mine and in the marketing of its ore is an advantage, because of high market prices, an aerial system could be put into operation much faster than any surface system and would be delivering the ore months before the road or grading work could be finished.

The transportation of the ore from the mines to the nearest railroad might not be found to be the limit of this service, for at times and in certain undeveloped localities it might pay to carry the load farther to a district of better rail service. The distance of handling might today be limited to 300 or 400 miles because of the poor economy of carrying too much fuel, but there is reason to believe that with great load capacity and machines developed for this class of service, this range could be increased without too much loss in economy to 500 miles. To obviate the necessity of landing with a great load of ore, the machines could fly low over the receiving yard and drop their burden from the air. Where the haul was short, several round trips from the mine to the depot might be made with no landings at the latter, and time and the wear-and-tear incident to landing could thus be saved.

AERIAL PHOTOGRAPHY AND MAP MAKING.

One of the uses of aircraft that the war has done the most to develop to its present high state of accuracy is aerial photography and its application to the making of mosaic maps. Developed from the necessity of gaining accurate information as to the location and nature of enemy gun emplacements, fortifications and supply lines, the science of aerial photography has become such an exact one that not only can it be used to get true topographic maps, but it can be applied in the making or checking of maps and mapping observations. The bulk of this work, and all interested in the furthering of flying throughout the country are hoping that much of it will be done, will probably be diected by the Government through its military or civilian personnel. It is not inconceivable, however, that companies engaged in the publishing of maps of the various parts of the country, such as Rand, McNally & Co., could find a market for better maps based on aerial photographs.

Owners of great ranches and plantations might find it of value to have the added insight of their possessions and the correlation of their various sections that would be afforded by a complete mosaic map. Advertising literature and descriptive maps of cities, resorts and real estate developments made by the aid of actual aerial photographs would undoubtedly possess enough value to warrant the expenditure necessary to compile them. In surveying undeveloped country for laying new railroad lines through it, the airplane would not only be a valuable adjunct in transporting the surveying parties and supplying them with necessities, but would aid in the making of their contour maps.

OTHER MISCELLANEOUS USES.

Among the miscellaneous uses that we may hope to put airplanes to, come those of supervision and exploration. While in many of its aspects this work would dovetail with the photography previously outlined, in other ways it presents new fields. Consideration is being given today by the Government to the patroling of the great National Forest reserves by airplanes driven by or carrying an expert forest ranger. A greater check on forest fires could be exerted by this means and in that way much natural wealth conserved. More ground could be covered with smaller personnel, and reports of fires by wireless from the air to a central receiving station would expedite the rushing of fighting crews to the scene of the impending catastrophe.

The inspection and supervision of large properties is made more efficient and rapid by the employment of an airplane by the manager. It is reported that J. P. Morgan has bought a plane and engaged a pilot to aid the manager of some of his large wheat lands in keeping in touch with his work. Policing operations, both state and municipal could be aided by airplane squads. State constabulary could throw a force of men into an isolated town where a strike or riot impended, by the use of large fast machines kept at central flying grounds. In the exploration of undeveloped country for following waterways or determining suitable waterpower developments, airplanes would provide vision and perspective to the pioneers.

USE OF AIRPLANES FOR SPORT.

Among the last and what has appealed to so many as the first and best use to make of our present aircraft is the sporting development. Undeniably there is a field here, and had the war not intervened it would be further advanced. For customers the producers of sporting types of airplane will surely have many of the returned and discharged military aviators. Most of them would probably enjoy the possession and use of a fast, able little craft, but unfortunately an airplane will always be more expensive than a motor car and

hence few but the wealthy will be able to indulge their fancy.

One of the first obstacles to pleasure flying is the fact that suitable flying fields are not numerous or located in respect to each other in such a way as to make possible an ordinary jaunt of an afternoon. Flying in the vicinity of a field soon becomes tiresome. One way out of this difficulty is through the use of machines of the flying-boat type. Coastal waters, inland lakes and rivers provide ample landing room for sportsmen. Sport flying will not doubt increase in popularity in spite of its cost and probably be fostered by the Government. The enlargement of the landing facilities provided by the mail routes and commercial lines will assist. That it will ever approach the magnitude and popularity of motoring seems improbable; skill in flying is not possible of attainment by everyone; the hazards of flying can be combatted only by the employment of elaborate precautions beyond the means of individual fliers.

CHANGES IN PRESENT EQUIPMENT.

Having covered in general the uses of aircraft, we approach now the subject of the initial developments that are necessary before entering the field of commercial endeavor. These in the order of their importance are:

(1) Engines
(2) Airplanes
(3) Means of navigation
(4) Landing grounds
(5) Legal questions

As I expect to cover the future developments later, I will confine myself here to a summary of what changes, if any, we must make in our present equipment and methods.

Our best engines at present, as exemplified by the Liberty Twelve, seem to give promise, if properly handled and not overtaxed in power or length of service without overhauling, of giving satisfaction in regular service.

Our airplanes, of course, need considerable reworking to fit them for carrying passengers or inert cargoes, except possibly in the case of smaller machines used for special service. Some of our planes, built to give the ultimate in performance from a military standpoint, possess unpleasant features when applied to peace-time uses. These planes will be worthless as far as everyday use is concerned. Others will require only a changing of interior arrangements. Bomb compartments will be replaced by comfortably appointed cabins or conveniently arranged cargo holds. Accessibility and ease of replacement of wearing parts will be given prime consideration in redesigning these machines.

Our navigation means probably call for the most immediate developments. Air compasses now in use are not thoroughly satisfactory at all times and in all weather. Radio direction-finders have been developed and seem to promise a more accurate and dependable method of keeping a true course in flying across country above the clouds or in a rain or fog. Better maps are necessary at once. Present-day maps are usually lacking in true accentuation of natural landmarks such as rivers and mountains. Confusion is caused by the omission of some marks and the inclusion of others when perhaps both look to be of the same magnitude when observed from an altitude of 10,000 feet or more. Cities flown over should be marked in some way to be readily recognizable by night or day.

Means of signaling the location of a field are necessary in a fog. Since most fogs are close to the earth, captive balloons riding above the fog in daytime, or star lights shot above the fog at night, will make it possible for the aviator to find his field. Proper and adequate means of lighting fields for night flying are advisable, since in some kinds of service this will present advantages over day flying.

Radio lighthouses along established routes sending out distinctive signals at regular intervals will aid the pilot in checking his position, which may be rendered uncertain by unknown wind conditions and loss of visability of the ground. Landing fields should be provided at reasonable intervals along the course of aerial routes. An endeavor should be made to locate suitable fields as near to town as possible in all cities contemplating airplane service, as a field distant from the center of a town tends to offset the time-saving of aerial travel. The shorter the run the more will be the magnitude of the disadvantage.

Serious contemplation should be given by the proper representative bodies of the State and the Federal Governments to the legal aspect of aerial transportation. Uniform laws governing the behavior of machines in the air and when alighting are needed, as well as inspection regulations to safeguard the public and eliminate ignorant and foolhardy operators. Proper instruction and examination of pilots are necessary; while the examination should not be so exacting at this time as to be unjust, it should be and can be thorough enough to safeguard against unsuitable and incapable operators.

FUTURE DEVELOPMENTS IN AIRPLANES.

It seems safe to assume that the uses of aircraft will expand rather than contract. This would indicate that we shall always have as many different sizes of machine and engine as now. Small single-engine planes will continue to attract sportsmen, will be used in special service and even in mail or passenger lines between small towns. Multiple-engine machines, however, possessing, as they do today, the added safety of being able to continue flight when one engine stops, seem certain to come more into use for all regular systems requiring the maximum of safety and dependence. Even though engines develop considerably in reliability, as they must and will, this type of airplane seems bound to predominate from other considerations. The size of the multi-engine machine will therefore probably vary more than at present. Starting with small two-passenger twin-engine airplanes, we shall probably have two, three, four and five-engine planes with horse-powers up to 5,000 and useful loads up to 20 tons, operating in different services in the near future.

As to the speeds that we may expect the machines of the future to attain, it appears that while more efficient machines and engines will undoubtedly increase the maximum possible, many types will be slow. Where a service is operated over country not possessing fast surface transportation, or over broken country and large bodies of water, the slower plane, say that having a maximum speed of about 80 m.p.h., will be the most economical. The attainment of higher speeds will always mean the lowering of the useful load carried. Where there is good rail service, or other conditions call for the maximum speed, we may expect to find planes in operation making with their full load anywhere from 150 to 200 m.p.h. Speed does not mean less dependence or safety but more often surer and safer service. It does, however, except in certain instances, spell higher costs per pound of load carried.

The tendency in engines, as far as their size is concerned, seems still to be toward greater power. What the limit will be is hard to predict, since it is restrained somewhat by developments in other directions. Unless radical changes in the methods now used in the making of air propellers occur, it does not seem that units larger than 1,000 h-p. will be practical. Two or more propellers driven from one powerplant by shafting or other means may, however, make it possible to double or treble this figure, lacking any developments in air screw construction.

As to new developments in airplane design, aside from larger or faster machines, it is difficult to see that this will follow any new or startling lines. The problem of descending and arising vertically with heavier-than-air craft, while probably not impossible of solution, seems to present insuperable difficulties. Very likely compromises will be effected which will permit airplanes to land in more restricted fields and in terrain of a rougher character than is now advisable. Lifting screws, air brakes, variable camber, variable area and better landing gears may be used in the solution of this problem.

Refinements of structures by more careful design or employment of better materials will undoubtedly continue and

will, by decrease of weight and head resistance, give greater speed ranges or greater load capacities.

Developments in engines seem to point toward the maintenance of power with increase in altitude and the consequent increase of speed and miles per gallon of fuel. Some success along this line has been attained already, and practical solutions appear to be forthcoming soon. More reliability in engines and the possibility of longer running without overhauling are of such advantage in commercial work that efforts will surely be bent in this direction. Better fuel economy will be sought not only from the fact that costs will be cut in this way but because weight will be saved by the reduction in the amount of fuel carried and the space gained will be available for more cargo or more comfort for the passengers. The three main developments in the engines then would seem to point to a higher weight per brake horse-power at sea level, but, of course, the maintenance of power at great altitudes and the lowering of the fuel consumption should offset this and perhaps eventually put us ahead of the present low-weight engine unit.

In the development of accessories and safeguards the field is broad and offers many opportunities. Automatic controls for the relief of the pilot seem certain of early attainment. Safeguards against fire and leakage from fuel tanks are well developed now, although not always applied. Improvement in both as to effectiveness and weight can be expected.

Muffling of engines, heating and ventilating of the cabins and housing-in of operators without restricting their vision will all come shortly and add to the efficiency of the pilot by reason of the increased comfort and freedom.

More durable materials for the covering of wings and bodies, protective coatings and the like will lower the present high rate of deterioration.

SERVICE COST DATA.

No doubt you have all at one time or another thought that you mght like to take a trip in a passenger-carrying machine. You have no doubt wondered what the initial costs would be and what the rate per passenger-mile can be expected to be in the near future. With this thought in mind I have prepared the following brief cost calculations on a problematic service between Cleveland and Detroit. The costs include all operating and overhead expenses of a complete operating company. For this service I have assumed the use of one of the Glenn Martin Co.'s twin-Liberty, 10-passenger planes equipped with pontoons for water landing. I have done this rather than use the land machine as in both Cleveland and Detroit suitable landing fields are too far from the center of town. Also, with a water machine no hesitation would be felt in taking a straight course from the one town to the other. If a land machine were used, prudence would dictate the following of the shoreline, with the increased distance thus made necessary, combating the time saving of the service. It should be understood, however, that this particular service is not the best example as to economy or locational advantage. Moreover, costs over the water will be higher than over land because of the poorer efficiency of water machines. That the estimates shown can be bettered for more advantageous service is possible of proof.

CONDITION OF FLIGHT.

The distance is assumed to be 100 miles.

The high speed of the plane full out will be 105 m.p.h.

Regular flying will always be conducted at a reduced speed of the machine and the engines. This speed will average about 95 m.p.h. when each engine is delivering about 310 h.-p.

Schedule flying time will be based on this throttled speed, less 15 m.p.h. Scheduled speed will then be 80 m.p.h. and schedule time for the trip 1¼ hours. Schedules can be maintained against head winds up to 25 m.p.h., by running full out. As winds above this speed are occasional and usually accompanied by bad weather for flying, schedule time should be maintained on over 90 per cent of the flying days.

In figuring the costs of operation and the depreciation of the machines and engines, this schedule time of 1¼ hours per trip will be used, although the majority of runs will be made in less time than this. This will provide a factor of safety and cover idling of machines on the water.

We will assume that flights will be made 170 days out of the year, or about 75 per cent of the time. Further, we will consider that our average load will be eight people, or 80 per cent of the maximum.

The gasoline consumption will run 26 gallons per hour per engine or a total consumption per machine of 52 gallons per hour. The total oil consumption should not exceed 2 gallons per hour.

SERVICE.

Assuming that the amount of traffic will permit the operation of two machines, each making six trips a day, three machines a year will enable this service to be maintained, as this would allow each machine a yearly flying life of 100 days, with 90 days for repair out of the 270 flying days in the year. We will assume that the total life of the machine is 1350 flying hours, and that to keep it in the air this time 15 per cent of the original cost is expended in replacement parts. Labor and material for fabricating other parts will be figured also.

We will assume that to keep each machine in the air 1350 hours two sets of engines will be used and junked. The total running life of each engine would then be 675 hours. We will assume that in the life of each engine it is completely overhauled six times and that at each overhauling replacement parts equal in value to 10 per cent of its cost are used in addition to other labor and material for repairs.

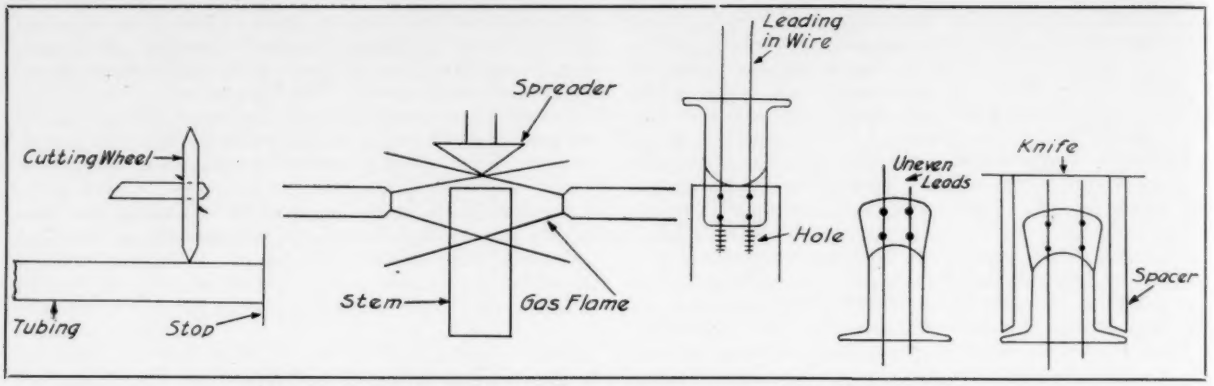
TIME SCHEDULE

	Leave Cleveland	Arrive Detroit	Leave Detroit	Arrive Cleveland
Machine No. 1 Pilot.....A	7.00a.m.	1 8.15a.m. A	2 7.00a.m. B	2 8.15a.m. B
Machine No. 2 Pilot.....B	9.00a.m.	2 10.15a.m. B	1 9.00a.m. A	1 10.15a.m. A
Machine No. 1 Pilot.....A	11.00a.m.	1 12.15p.m. A	2 11.00a.m. B	2 12.15p.m. B
Machine No. 2 Pilot.....C	1.00p.m.	2 2.15p.m. C	1 1.00p.m. D	1 2.15p.m. D
Machine No. 1 Pilot.....D	3.00p.m.	1 4.15p.m. D	2 3.00p.m. C	2 4.15p.m. C
Machine No. 2 Pilot.....C	5.00p.m.	2 6.15p.m. C	1 5.00p.m. D	1 6.15p.m. D

It is seen then that four pilots are operating every day, each making three flights totaling 3¾ hours in the air. Six pilots will be required to give the proper relief and reserve.

Here follows a detailed statement of capital invested and expenses, which is omitted. The estimated cost per passenger mile is $0.18, total investment, $349,800 and percentage of profit on investment 30.—EDITOR.

Assuming larger and faster land machines working up to the limit of their capacity, it can be shown that passengers can be carried at a good profit as low as 10 cents per passenger-mile. The fuel consumption mentioned is a little high because the engines are throttled and the Liberty burns 33 gallons per hour full out, developing 400 h.p. Throttling down to 310 h.p., the engine speed is approximately 1600 r.p.m. We have no accurate results on gasoline consumption at that speed, but I know that going to Washington we burned a little more than 26 gallons per hour per engine at about 1600 r.p.m. I think that consumption could be reduced.



FIGS. 1 TO 5. FIRST STAGES IN THE MANUFACTURE OF HEADLIGHT LAMPS

1. Cutting tubing for the lamp stems with an emery wheel. 2. Flaring end of tubing for junction with bulb after assembly of filament. 3. Method of inserting leading-in wires. 4. Uneven lengths of leading-in wires—often a result of cutting leading-in wires to exactly the required length. 5. Leads of uniform length insured by trimming after sealing in.

Improving the Automobile Headlight Lamp*

Details of Manufacture and Testing

By L. C. Porter

LAMPS that are intended for use with lens systems or parabolic reflectors must have the light source located along the axis, usually at the focal point, and it is readily seen that the manufacturing methods must be adopted which will insure uniform dimensions in lamps of a given type, as only with such lamps can replacements be made quickly and satisfactorily. The following article describes the manufacture of automobile headlight lamps stage by stage, indicating that every effort has been made to secure a product as nearly uniform in dimensions and performance as is possible.

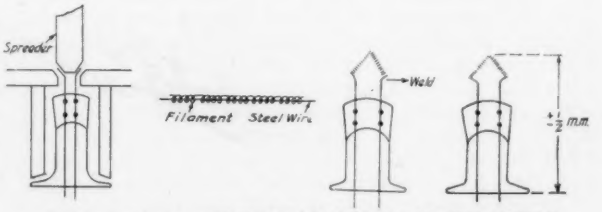
During the war the greatest need in the manufacture of headlights was quantity production with minimum labor and time. Now, however, the pressing need for minimum labor is past and more attention can be given to perfecting the quality, and uniformity of product is one of the things that is being given special attention. Since the armistice was signed an engineer has been appointed to study the manufacturing methods and suggest changes which will result in more perfect automobile headlight lamps. He has instituted a system of gages and inspections which is proving remarkably effective. It may be interesting to describe in detail the present method of manufacturing a typical lamp, say the 6-8-volt, G-12 bulb, 21-c-p Mazda headlight lamp and to point out recent improvements and call attention to the inherent variations required for practical manufacturing in large quantities.

The stem of the lamp is made from straight glass tubing received in long pieces. This tubing is gaged for thickness and diameter. It is then cut up into short pieces of the proper length for the stem, by pushing the end of the tube against a stop and then moving it to a rapidly revolving emery wheel, see Fig. 1.

The next operation is to put these short tubes into an automatic flare machine, which heats one end of the tube by means of a Bunsen flame and then spreads it out with a rotating metal plunger (see Fig. 2). Until recently this flaring was done by hand, resulting in a considerable variation in the spread of the flare and consequently in the length of the stem. With the automatic machine, however, the plunger enters a certain fixed distance and, being of constant diameter, there is less chance for variation in length. In order, however, to see that everything is working properly a certain percentage of all stems are gaged for length and the result of these tests are recorded.

*Reprinted from the *General Electric Review*, January, 1920.

The next operation is the insertion of the leading-in wires (see Fig. 3) in the stem. The glass tube is placed in a machine, flare end up, and the two wires stuck down into holes in the rod holding the glass. Occasionally one of these wires will be slightly bent, or a particle of dirt will get into one of the holes, thus preventing the wire from going in its full depth. After the wires are in place the glass is rotated and heated by Bunsen flames until soft and then the glass is pinched together to make the seal. Formerly the leading-in wires were cut to just the required length and when it happned that a wire did not go to the very bottom of the hole, the result was leads of uneven length on the mount (see Fig. 4). Now, however, all leads are made two millimeters longer than necessary, and after being sealed in the stem



FIGS. 6 TO 9. FURTHER STAGES OF MANUFACTURE

6. Leading-in wires being shaped ready for attachment to filament. 7. Forming filaments by winding on fine steel wire. 8. Shape and position of filament after being electrically welded to leading-in wires. 9. Permissible limits of variation in assembly of lamps.

are trimmed off by a semi-automatic machine which fixes the distance from the top of the flare to the ends of the leading-in wires (see Fig. 5) and assures leads of uniform length. This means a considerable waste of nickel, but the high cost thus entailed is warranted by the more uniform product obtained.

The next process is to bend the leading-in wires preparatory to welding on the filament. This used to be done by hand, but is now accomplished semi-automatically by a metal plunger, the stem being held against the top of the flare to keep the overall length constant (see Fig. 6). The stem is now ready for the filament, which is made as follows:

The lamp under consideration being a 6-8-volt, 2½-ampere lamp, it will be gas-filled and will require a coiled filament. To make this the tungsten wire is automatically wound around a fine steel wire. The winding machine makes a constant

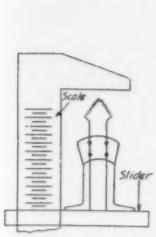


FIG. 10. METHOD OF GAGING OVER-ALL ASSEMBLY LENGTH

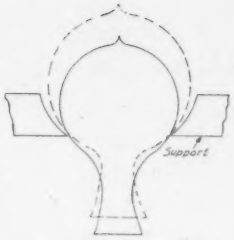


FIG. 11. HEIGHT OF BULB IN MACHINE VARIES WITH DIAMETER

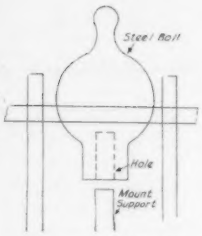


FIG. 12. MEANS FOR MOUNTING FILAMENTS IN CENTER OF BULB

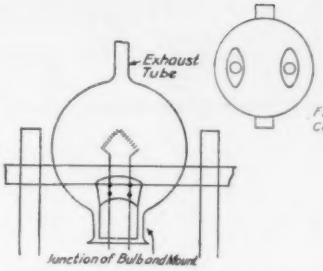


FIG. 13. BULB IN POSITION READY FOR MELTING TOGETHER

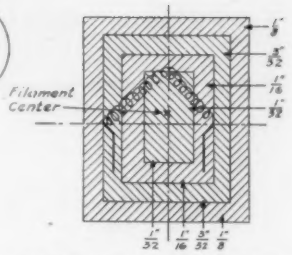


FIG. 14. LAMP BASE, POSITION OF LEADS AND PIN

FIG. 15. CHART FOR DETERMINING POSITION OF LIGHT CENTER

number of turns, then allows the coil to pass along, leaving a short piece of straight wire before making another coil. The result is a series of connnected coils wound on a steel wire, as shown in Fig. 7.

These coils are then cut apart with a pair of pliers, this work being done by hand and there must necessarily be some slight variation in the length of straight wire beyond the coil, though a standard of two millimeters has been set. These little coils are next bent by hand, into a V shape, the operator picking out, as nearly as practical, the center of the coil as the bending point.

The filament coils are then put into a hot acid bath which dissolves out the steel core on which they are wound. The filaments are then heat treated at 1000° C. in hydrogen gas, which removes all impurities and leaves them ready for mounting.

The filament is now laid on the leading-in wires and is semi-automatically electrically welded to them (see Fig. 8). In this process it can be seen that there must necessarily be some slight variation in the length depending on the angle at which the filament is bent and the exact position in which it is laid on the leading-in wires. The variation in overall length of the amount which has been set to take care of these conditions is plus or minus one-half millimeter measured from the bottom of the flare to the point of the filament (see Fig. 9). This is gaged by a sliding rule (see Fig. 10), the mount being placed on the slide and brought up until the point of the filament touches the upper stop. The mount is now ready for sealing in the bulb.

The bulb is blown in a mold, but, strange as it may seem, the diameter of the bulbs will vary somewhat. In the mounting machine the bulb is held in a ring and the height of the bulb will vary slightly with its diameter (see Fig. 11).

In order to set the bulb properly a steel ball, of the exact size of a correct bulb, is made with a hole in it which allows the rod that holds the mount to rise exactly the right distance to bring the filament center in the center of the bulb (see Fig. 12). This device is used in setting the machine. The mount is then put on the rod and the bulb placed down over it (see Fig. 13). The bottom of the bulb and the flare of the stem are then melted together by rotating them in a Bunsen flame. After this is done it is necessary to "work" the glass at the joint a little to prevent cracking. This used to be done by removing the bulb and mount while still hot and drawing the latter down a little by hand, thus stretching the glass. Now, however, it is done by blowing compressed air in through the exhaust tube and stretching the joint by expanding it. There must necessarily be some

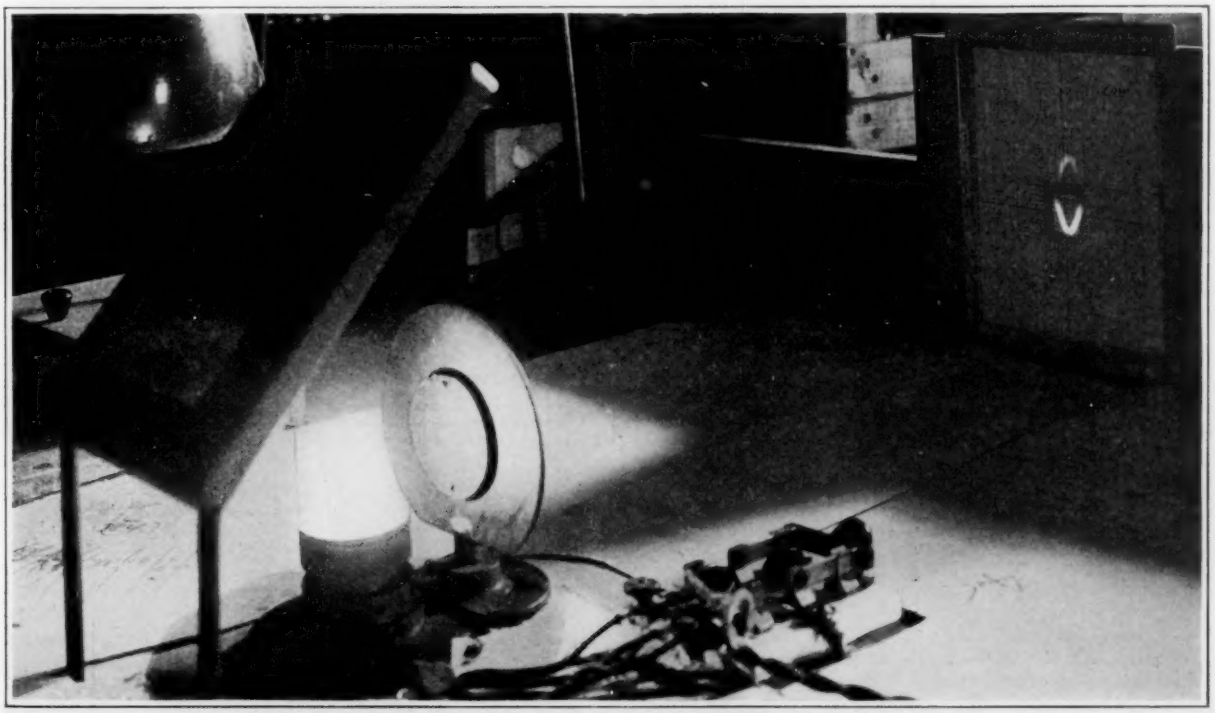


FIG. 16. OPTICAL DEVICE FOR TESTING LIGHT CENTER LENGTH OF LAMPS

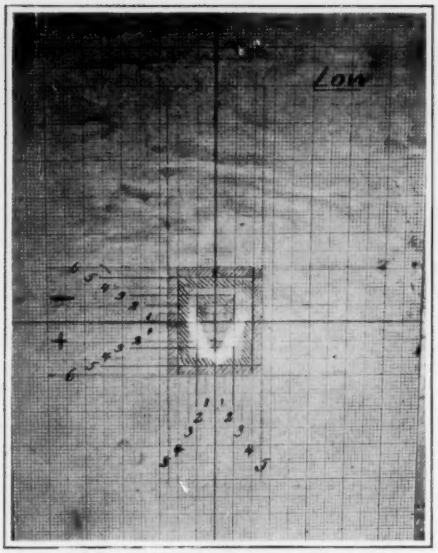


FIG. 17. TEST FOR VARIATION IN LIGHT CENTER LENGTH

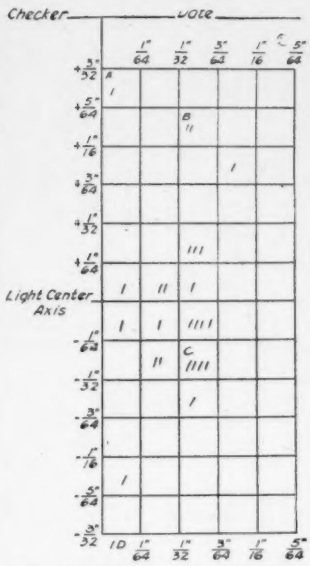


FIG. 18. RECORD OF A LIGHT CENTER TEST

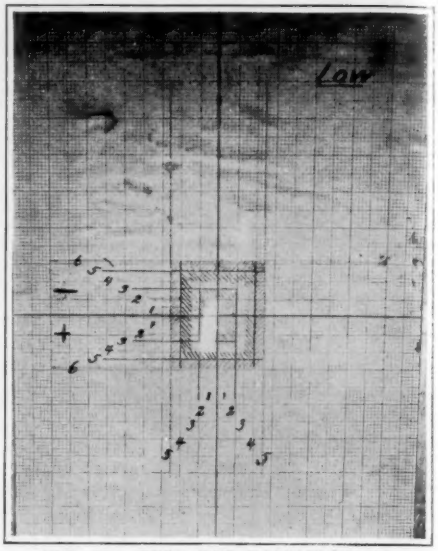


FIG. 19. TEST FOR VARIATION OF FILAMENT FROM AXIS

variation in length in that process and also the shape of the neck of the bulb will vary somewhat. The bulb and the mount are now ready for the base.

The two leading-in wires from the stem are stuck through the holes in the bottom. These holes are at 90 deg. from the pins on the base and thus determine the plane of the filament (see Fig. 14). The base is filled with glue and set into a heater to harden the glue. In this process if the wires happen to be slightly bent or twisted, the plane of the filament will vary somewhat from 90° from the pins, and even if the operator twists it around to 90° the wires are liable to cause it to spring back before the glue hardens. There must, therefore, be some leeway allowed in this respect. The slight change in shape of the neck determines to some extent the distance that the base will go up on the bulb before striking the glass.

It is easy, therefore, to see that with conditions as pointed out it is practically impossible to keep the light center length of the filament (distance between the nearer edge of the pins on the base and the center of the filament) to an absolute figure. The allowable tolerance in the light center length is 3/32 in.; *i. e.*, if the center of the filament is not more than 3/32 of an inch above nor more than 3/32 of an inch below the 1¼-in. distance from the top of the pins, it is acceptable. The filament must also lie entirely within 5/64 in. of the axis of the lamp passing through the center of the base and the tip. A certain percentage of every run of lamps is tested for these variations.

The device for testing the light center length consists of an optical projector which throws an image of the filament on a calibrated screen, see Figs. 16, 17 and 19. From this it can be easily determined just where the center of the filament comes. The center of the filament is taken as the central point of the triangle formed by the two filament legs and a line joining the points where they are welded to the leading-in wires. The testing device enables the lamp to be rotated 90° so that the filament image can be inspected as to its axial position.

In recording the test of a batch of lamps the form shown in Fig. 18 is used, which shows that of 26 lamps tested, one had a light center length of 1 11/32 in. (1¼ in. 3/32 in.) with some part of its filament 1/64 in. off from the axis (Square A); two had light center lengths of 1 5/16 in. with some part of the filament 3/64 in. off the axis (Square B): four had light center lengths of 1 7/32 in. (1¼ in. 1/32 in.) with some part of the filament 3/64 in. off of the axis (Square C) and one lamp had its filament outside of the light center length limit of 3/32 (Square D), etc.

Records are kept of all the tests and inspections during the entire process of manufacture and these are plotted as curves so that the engineer in charge can see at a glance just how the production is running and whether the various parts of the lamps are becoming more or less uniform.

The lamps which do not come within the specifications are opened and the defect corrected where possible. In cases where this is not practical the lamp is destroyed.

MAKING OLD BOLTS AND NUTS FIT FOR RE-USE.

IT has always been the object of German railway management to reduce the cost of upkeep, but in the present conditions it is more essential than ever before.

The article is specially concerned with damaged bolts and nuts from the permanent way—these formerly went direct to the scrap heap. The methods for preventing this waste, which have been devised by Mr. Gerz, of Witten, deserve publicity. Bolts in which the thread had become worn were straightened, the defective part cut off, and re-threaded, thus making a perfect bolt of shorter length. The nuts, when rusted on, were cut off, heated in a furnace to loosen them on the bolt, and then re-tapped. In some cases nuts and bolts can be heated in a gas furnace, so that when hot they can easily be separated. Several photographs show the various types of bolts and nuts which were again rendered fit for use. These combined processes have saved the railway management very large sums.—Fabian, *Zeitung des Vereins Deutscher Eisenbahnverwaltungen*, Dec. 31, 1919. Abstracted by the *Technical Review*.

A NEW VEGETABLE IVORY.

A RECENT number of the French Bulletin of the Colonial Office gives a description of a new form of vegetable ivory, which can be used in European industry in place of the coroso. This new substance is produced by the kernel of an edible fruit growing upon a palm of the upper Senegal-Niger territory, the *Borassus ethiapicum*. The kernel is 7 or 8 cm. long and 5 cm. broad, thus permitting the cutting of balls or plates of considerable size to be used in marquetry, or the making of dominoes, piano keys, buttons, etc. The kernel becomes extremely hard when thoroughly dried; as a proof of this it is stated that it is at the present moment being used as building stones for the making of the houses of native chiefs, while it is expected that the future cathedral to be built at Dakar will have tinted pillars constructed of these kernels.

Automobile Headlighting Regulation*

Experiments to Determine How Present Laws May Be Improved

By Clayton H. Sharp and W. F. Little, Electrical Testing Laboratories, New York

THE subject of automobile headlighting regulation is one which interests us all from at least two standpoints. We are interested from the engineering standpoint inasmuch as we have a problem in illuminating engineering to deal with. We are also interested in it from the point of view of the public; that is, as users of the highway both on foot and in motor cars.

In the days when the headlighting of automobiles was done by acetylene gas, the headlighting problem was not what it is today. Acetylene headlights gave a rather limited illumination on the road, and at the same time did not produce the intense and blinding glare with which we have unfortunately become familiar since the advent of the electric incandescent lamp as a source of light for this purpose. The incandescent lamp with highly concentrated filament, when used at the focus of a parabolic reflector throws a beam of very high intensity—a beam which is capable of giving an excellent driving light, but which under many conditions produces an insufferable and intolerable glare dangerous to the other users of the highway.

INEFFICIENCIES OF EARLY LEGISLATIVE CONTROL.

As a result of protest against the dangerous glare of powerful headlights, legislation has been enacted from time to time for the purpose of controlling the use of such headlights. The exact method of control which should be adopted had to be devised as an entirely new matter, and hence legislative enactments were in the beginning very broad and indefinite. In general the laws stated, and do yet state, that headlights should not produce a dangerous glare or dazzle. Legislation of this character, however, had very little effect in eliminating the evil inasmuch as neither the legislators nor the traffic police officers nor the public knew what were the necessary means to adopt to accomplish this elimination of glare while retaining the light necessary for the safety of all users of the highway. To make the provisions more definite further legislation has been passed requiring that no portion of the direct reflected beam of the headlights, when measured at a distance of 75 feet or more in front of the vehicle, should rise more than 42 inches above the level surface on which the vehicle might be standing. In some states it was provided that state officials should pass judgment on various types of headlighting equipment and should approve or disapprove them in accordance with whether they meet the above requirements or not. The difficulty which was met in the case of this type of legislation was that it is practically impossible to say what the limits of the direct reflected beam are. With certain types of headlight glasses, namely, the scattering or diffusing type, the beam is broken up, so that the portion which comes by reflection is indistinguishable from the portion which proceeds from the lamp itself. Makers of this type of device have claimed that there is no direct reflected beam, a claim which evidently leads to an absurdity. Furthermore, the difficulty arises that if all of the direct reflected beam from headlights

*Delivered before the Joint Meeting of American Institute of Electrical Engineers and the Illuminating Engineering Society, December 8, 1919, at the Engineers' Club of Philadelphia. Reprinted by courtesy of the *Journal of the Engineers' Club of Philadelphia.*

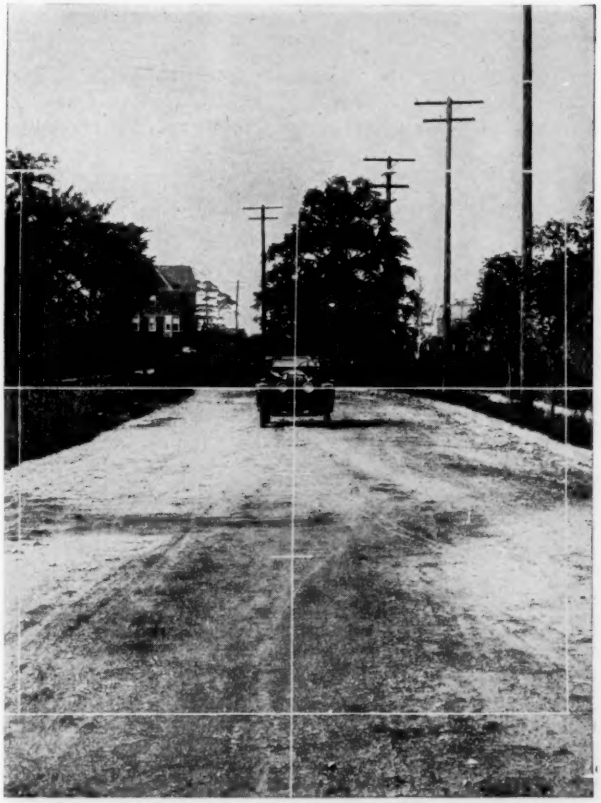


FIG. 1. CAR 200 FEET AWAY

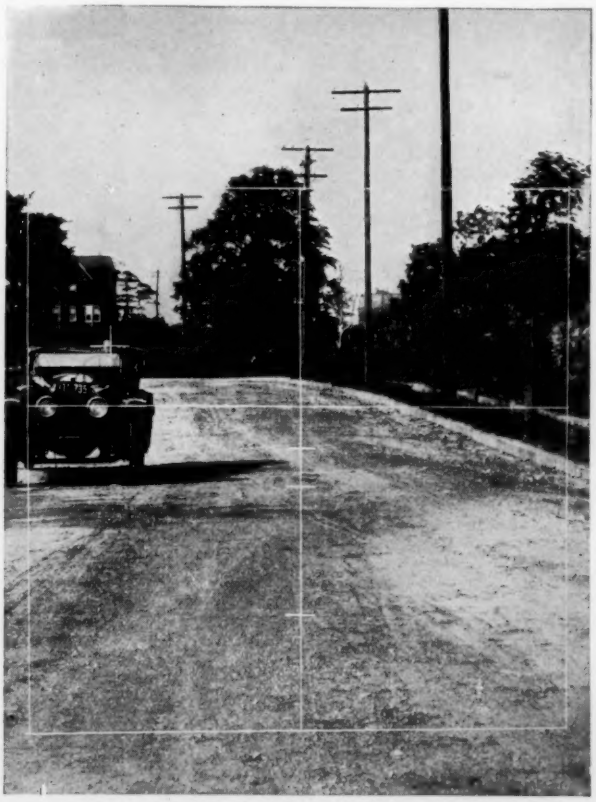


FIG. 2. CAR AT 100 FEET IN PASSING POSITION

FIG. 3. CAR TURNING OUT TO PASS

were cut off at a level 42 inches above the road, it is doubtful if the remaining light above the 42-inch line would be sufficiently strong to enable the driver to proceed with safety to other users of the highway. The judgment of administrative officials under this proviso was in general arbitrary and personal, had no scientific basis, and hence no basis on which uniformity of judgment could be founded. In general this type of legislation has been found ineffective.

VARIED INTERPRETATIONS OF PRESENT LAWS.

There have been some attemps to reduce the matter to a scientific basis. In St. Louis, as a result of a decision reached that headlights of more than 1200 candlepower would produce dangerous glare, a huge photometer was built and set up in such a way that a car could be placed in front of it and the beam of the headlights measured to see whether it came above or below 1200 candlepower. If it came below, the headlights were approved. In the Province of Ontario, as a result of certain experiments, the glare limit was fixed at 800 candlepower. In Vermont, the University of Vermont conducted experiments on headlights, but it is not evident from their report that approvals of headlighting devices were based strictly upon the findings of their tests.

Matters were in this state when the Illuminating Engineering Society appointed a Committee on Automobile Headlighting Specifications. The work of this committee which has been directed toward the formulation of specifications for acceptable headlighting devices will be described in some detail. This committee decided that the first thing to do was to get some line on how much light is necessary to comply with the general provisions of a headlighting law. At the time New York State was just in the process of revising its legislation on these lines, and the New York State Law was taken as a point of departure. This law provided in brief that the headlights must render visible a person, vehicle or other substantial object 200 feet directly in front of the car, and that no dangerous glare or dazzle should be produced. The committee therefore decided as a first step to make experiments which would give some information as to the limitations of the light required to comply with the provisions of the law. In the first place, how much light is necessary to render visible an object 200 feet directly in front of a car, and second, what is the limiting value of the beam in a driver's eye beyond which the glare becomes intolerable?

Experiments were conducted on a dark road. A pair of headlights arranged with a storage battery, a rheostat and an ammeter were set up on this road, and back of them a seat representing the driver's seat. A similar pair of headlights similarly equipped were set up to the left of these 100 feet down the road, the rheostat, however, being under the control of the person occupying the driver's seat behind the first headlights. About fifty observers were employed, these being illuminating engineers, automobile engineers, private car drivers, chauffeurs, traffic officers, state officials and others, all of them competent to form intelligent judgment on the question at hand. The operation was as follows:

The observer sat in the driver's seat and adjusted the rheostat of the lamps in front of him until he had sufficient light to see men walking across the road 200 feet away. The value of the light so required was determined. Maintaining the light at that value, he switched on the other pair of headlights facing him and adjusted their brightness until he reached a point where he considered that any further light would produce a glare beyond the limits of toleration. The light reaching his eyes under those circumstances was also measured.

A study of the fifty sets of entirely independent results so obtained revealed, as was to be expected, very wide variations. For purposes of visibility the lowest man wanted 1200 candlepower and the highest 18,000. With respect to glare the lowest man would stand but 80 candlepower, while the highest accepted 800 candlepower. Of course, these were personal judgments, but the results tell us what we want to know, for the definition of a satisfactory headlight depends largely on the driver's own idea of what he wants, and so the data so obtained, while referring only to stationary lights, and while showing marked inconsistencies, were of great value.

HEADLIGHT ACCEPTABILITY TESTS.

About this time the Secretary of State of New York applied to the committee for specifications under which acceptability

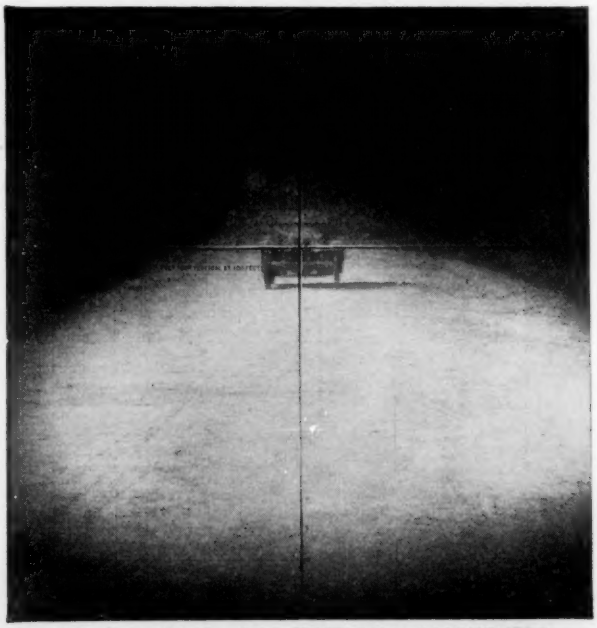


FIG. 4. SAME AS FIG. 1 WITH BEAM PRODUCED BY PRISMATIC FRONT GLASSES

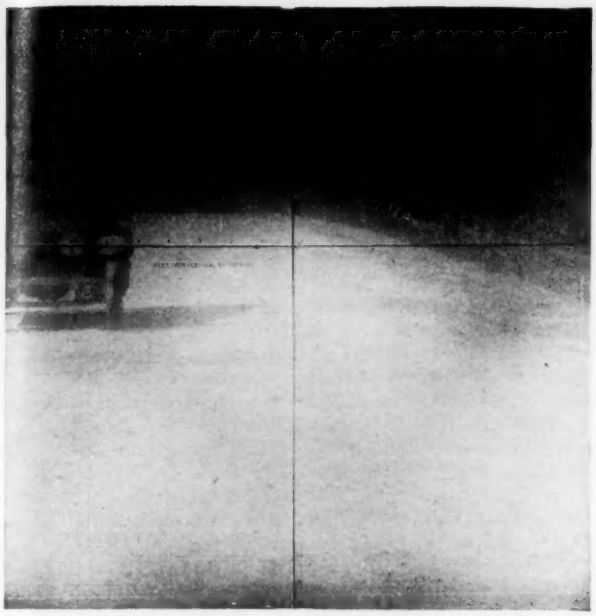


FIG. 5. SAME AS FIG. 2 WITH BEAM PRODUCED BY PRISMATIC FRONT GLASSES

tests of headlighting devices might be made for him as provided in the law. In order to arrive at the limitations which must be incorporated in such specifications, the committee did not consider that the results of the stationary test were sufficient, but proceeded to inaugurate running tests in which two cars were used similarly equipped and in which the beam was studied photometrically. As a result of numerous running tests with varied beams and with skilled observers the conclusion was reached that for the purposes of a legally restrictive specification the values which had been found as outside values in the stationary test might be adopted. That is to say, it was clear that the beam down the road should not be less than 1200 candlepower, which was the requirement of the lowest man in the stationary test. It was also evident that the glare reaching the eye of an oncoming driver at a distance of 100 feet should not be greater than 800 candlepower, which was the highest glare value accepted by any of the observers in the stationary test. Therefore, with these values fixed, a specification was drawn requiring a candlepower in the beam between the horizontal and the road level 200 feet from the car not less than 1200 candlepower, also restricting the beam at a point 100 feet in front of the car, 7 feet to the left of the axis of the car and 60 inches above road level to 800 candlepower. It was also provided that the candlepower directly in front of the car and 60 inches above the road level should not exceed 2400. The reason for the adoption of these positions for measuring the glare are as follows: If 800 candlepower is the limiting value for tolerable glare at 100 feet, as the distance becomes greater this value can be increased. For instance, the corresponding value at a distance of 200 feet would be four times as great or 3200 candlepower. It was considered, therefore, that directly in front of the car a higher value than 800 could be adopted, because an on-coming driver would never be directly in front of the car at as short a distance as 100 feet. Therefore the value of 2400 candlepower was allowed. At a distance of 100 feet the on-coming driver must have turned out to pass. His eye, therefore, may be assumed to be approximately 7 feet to the left of the axis of the car and at a distance of 60 inches above the roadway, and at this point the light is restricted to 800 candlepower. It will be noted that a height of 60 inches is chosen, which is a representative height for the driver's or pedestrian's eye above the road level rather than 42 inches, which is a figure of no particular significance.

Specifications including these limits were adopted by the Secretary of State of New York after a public hearing in which the various interests were represented and presented their views. Since that time the State of California has adopted the same values.

RECOMMENDED ALTERATONS IN PRESENT HEADLIGHT SPECIFICATIONS.

The Committee on Automobile Headlighting Specifications has never been satisfied that the value of 1200 candlepower for the driving light is sufficient, and at the time of the adoption of the 1200 candlepower figure the members went on record as favoring a higher value which, however, it was believed inadvisable at that time to put into the specifications. Since that time the committee has definitely recommended that the driving light should be four times as intense, namely, 4800 candlepower as the minimum. It has also recommended that headlighting specifications provide for a proper spread of the beam toward the right of the axis of the car; this for the purpose of revealing pedestrians on the road and of showing the curb and ditch. Its later recommendation, therefore, includes the proviso that 7 feet to the right of the car and The State of Connecticut has adopted these latest recommenda- The State of Connecticut has adopted these laest rcommndations of the committee and has made its acceptability tests in accordance with them. The State of Pennsylvania has adhered to the New York State practice, excepting that it has improved upon it by requiring that 100 feet ahead of the car and 7 feet to the right there must be a minimum of 800 candlepower, a proviso which is in accordance with the committee's ideas, but which does not go quite so far as the committee would like to go.

It should be understood and borne in mind that these specifications on the part of the committee are not intended to describe the best headlighting practice. They are intended to be applied to the restrictions applied by administrative officials and are drawn with the idea of working a minimum hardship upon those who already have made an attempt to comply with the requirements of the situation. Hence many devices which from the point of view of the illuminating engineer or of the electrical engineer or of the mechanical engineer are decidedly inferior, are capable of complying with these specifications. However, a strict compliance with them

FIG. 6. SAME AS FIG. 3 WITH BEAM PRODUCED BY PRISMATIC FRONT GLASSES

will insure that devices producing a really undue glare will be ruled off the road, and conditions to this extent will be greatly improved. Those who are using devices which, while they do not produce an undue glare, also do not produce good driving light, will after a time come to find that they are at a disadvantage by the use of such devices and will exchange them for better ones; that is, the bad devices will be ruled off the road, the fair to middling devices will gradually disappear, and it is reasonable to expect in time that motor cars will light the road reasonably well both from the point of view of the driver and from the point of view of others. One effect of the specifications is to encourage the efficient devices; that is, those which throw the light on the road where it is wanted and not over the entire surrounding scenery where much of it is wasted.

MODEL HEADLIGHT LAW.

The committee further in connection with the Committee on Lighting Legislation of the Illuminating Engineering Society has prepared a proposal of a model headlight law. This proposal contains a number of very interesting and important suggestions, one of which should be of great interest to motorists. This is that testing stations should be authorized or licensed, where the headlights on any car could be tested for a nominal sum. Garages, for instance, might undertake this work after having convinced the authorities that they have the necessary equipment and technical knowledge. Then traffic officers should be authorized to stop a driver whose lights appear to be glaring and to give him a summons to appear at one of these testing stations to have his lights tested within a certain time. This should have the effect of eliminating from the road all cases of glare excepting such as result from willful disobedience of the law, and those cases could readily be dealt with by ordinary legal processes.

It should be clear from the foregoing that a start has been made on the regulation of automobile headlights along scientific lines. With four states approving headlighting devices as a result of scientific tests made under specifications which are fundamentally the same, a beginning has been made toward interstate standardization which is a matter very greatly to be desired. Every state which adheres to this method adds a good deal to the accumulated results. It is to be hoped that through the influence of the various automobile associations, future legislation may be guided along these lines. It is only by adherence to scientific methods based on fundamentally correct experimental results and representing a satisfactory engineering compromise between the demand for more light and the demand for less glare that sound and permanent results are to be expected.

For purpose of demonstrating the points made, Mr. Little threw on the screen lantern slides showing, first, the appearance of a car on the road 200 feet away; second, a car turning out to pass another car—under this condition the headlights of the car are pointing at a considerable angle from each other; third, a car 100 feet away in the passing position. On the screen image of each of these slides was thrown the beam from an automobile headlight and this beam was modified by tilting the lamp, by putting on a prismatic front glass, and by putting on a scattering front glass. The results showed that the unmodified beam when placed horizontal would throw a bright light in the on-coming driver's eyes. The unmodified beam tilted would avoid this glare, but produce an insufficient light at the sides of the road. A prismatic front glass would divert the light toward the road, giving good road illumination and keeping down the glare and at the same time illuminate the sides of the road. A scattering front glass would produce a light more or less uniformly distributed over all objects in view.

Development of the Internal Combustion Engine*

Its Past, Present and Future

By T. Blackwood Murray

DURING the past 25 years there has sprung into being a branch of mechanical engineering which has already become an important subdivision, namely, the manufacture of light internal combustion engines for the propulsion of motor cars, motor boats, flying machines, and such like, and as I happen to be the first president of this institution directly connected with this branch of the profession, I feel that it is a great honor to that section that a motor car manufacturer should have been called to the chair of this institution, and it is natural that I should wish to direct your attention this evening to some of the features of mechanical transport.

Some 35 years ago Gottlieb Daimler conceived the idea of constructing a light high-speed internal combustion engine for the purpose of propelling a tricycle. At that time the only gas engines in existence were heavy, cumbrous prime movers, and built purely for stationary purposes.

A few years later the manufacture of this light Daimler engine was taken up by Messrs. Panhard and Levassor, of Paris, and some of them were exhibited at the 1889 Paris International Exhibition, and attracted considerable attention there. In the affairs of mankind it has been well said that it is only in the retrospect that we can properly appreciate a man's work and put its true value upon it, and looking back over the past 25 years one realizes how much the motor car industry owes to Panhard and Levassor, particularly the latter, for the very valuable work which they did in five years prior to 1894 in evolving a practical road carriage to be propelled by the Daimler engine. By that date they had evolved a vehicle which comprised a great many of the essential features of the standard gasoline motor car of the present day. For instance, the engine was mounted in front of the vehicle under a bonnet with the starting handle in front. From the engine the power was transmitted through a spring-actuated friction clutch normally in engagement, and disengaged by a pedal for the purpose of changing gear. Changes of gears were obtained by sliding into mesh suitable pairs of spur wheels mounted on parallel shafts. Three speeds and a reverse were provided, and a foot-brake operated by a second pedal, and a second brake operated by a hand lever. There was also a pump for circulating the cooling water. All these points are standard practice today, and are accepted as matters of course, but we should realize what an enormous amount of thought and ingenuity must have been expended upon the problem of conceiving practicable methods of applying the power of the Daimler engine to the propulsion of a road vehicle, and to invent and design suitable mechanism to accomplish these ends. That these devices have stood the test of time is indeed a great compliment to Monsieur Levassor's skill and ability. To refer more particularly to one of these mechanisms, namely, the sliding speed-change gear—this in the early days was greeted on every hand with derision, and an early decrease predicted for it. Indeed there are few engineers who have not at some time or other scoffed at its crudeness. Even Monsieur Levassor, when twitted about it, remarked—"*C'est brusque et brutal, mais il marche.*" The

*Presidential address before the Institution of Engineers and Shipbuilders in Scotland, November 18, 1919.

fact remains that it is today a proved and satisfactory device, and is indeed almost in universal use. With the enormous improvement in materials available since Levassor's day, and attention to the fundamental points of design, the gear-box of a modern vehicle gives little trouble even in the hands of an inexperienced driver, and with a moderate amount of skill gear changing can be effected noiselessly and without shock.

Closely following Levassor's work several other engineers produced motor vehicles propelled by these Daimler engines, or one of similar design, and in 1894 sufficient interest had been aroused to induce the *Petit Journal* to organize a race for motor vehicles between Paris and Rouen, and the laurels were easily carried off by the Daimler engines. There is little doubt that much more attention would have been given to the matter in this country had not the development of the motor car been rendered impossible by the Locomotives on Highways Act, which at that time only permitted a motor vehicle to be used provided it was preceded by a man on foot carrying a red flag, which limited the pace to 4 miles an hour. But for this fact I have no doubt that this country would have had a more creditable record in the early development of the motor vehicle. In spite of ridiculous and restrictive legislation, however, several progressive men either built motor vehicles of their own design or obtained from the Continent such crude models as were then being manufactured, and set out to evolve more practical motor cars. In the autumn of 1895 one of these experimenters was fined for driving his vehicle in Argyle Street without having a man in front bearing the red flag. It was not until the autumn of 1896 that the law was amended, and motor cars became legal on the highways up to a speed of 12 miles per hour in England and 10 in Scotland. Since that date the industry has gone steadily ahead in this country, though in the early days there was much prejudice to face and many difficulties to be overcome.

The car which won the Paris-Rouen race weighed about 1,300 pounds, and was fitted with an engine developing about 3½ horse-power; it therefore developed 1 horse-power per 370 pounds of weight. Today an average allowance for a passenger motor vehicle is about 1 horse-power to 80 pounds of weight, and a recent writer on this subject hazarded the prediction that, as a result of the influence of the development of airplane engines, the ratio would probably be increased to 1 horse-power per 56 pounds of weight within the next few years. This, however, does not indicate the record which has already been reached in this direction. Recently a two-seated light car fitted with an air-cooled engine has been put upon the market, which claims to have a ratio of 1 horse-power per 24 pounds of weight. The early Daimler gasoline engine fitted to the first Panhard-Levassor car was a two-cylinder engine operating on the Beau de Rochas cycle, and gave one impulse or working stroke per revolution, but the mechanical balance was poor. A few years later considerable advance was made by the introduction of the four-cylinder engine giving two equally-spaced impulses per revolution, and having a fair balance of moving parts. The great majority of engines used for car propulsion today are of this type. About 1903 a considerable advance was made by Messrs. Napier by the introduction of the six-cylinder engine, giving three equally-spaced impulses per revolution, and having a perfect mechanical balance. A properly constructed six-cylinder engine runs with great smoothness, and gives a reasonable equable torque. Quite a number of cars with eight-cylinder engines are now being built, and even twelve-cylinder engined cars are not unknown.

The early motor-car engines only ran well at one speed and approximately full load. This was largely due to the fact that these engines were fitted with carburetors having no automatic regulation, and only supplying a proper mixture to the engine under these conditions. At any other speed or load the mixture was either too rich or too poor to ignite with certainty. The ignition also was by means of hot tubes, which necessitated a fairly constant compression in the cylinders to be effective, and these early engines were consequently controlled by a hit-and-miss type of governor, which either gave the engine a full charge or none at all. The laws governing the flow of air and fuel were investigated, and compensating devices were devised to ensure that the mixture of fuel and air supplied to the engine would be of the desired proportions under all conditions, and some of the later devices attain this in a wonderfully simple fashion. The shortcomings of the hot-tube ignition as fitted to the earlier engines were soon realized, and within a few years it had entirely given place to electrical ignition. Bearing in mind the difficulties that had to be surmounted in evolving an electric generator of small dimensions and light weight, capable of generating throughout a wide range of speed an electric current at a pressure of several thousand volts, we realize that the modern high-tension magneto is really a marvelous achievement. There are, of course, other systems of electrical ignition, but I have referred to the principal type.

For no very obvious reasons the earliest engines had automatic inlet-valves, but these were unreliable, and were soon replaced by cam-operated valves, which could be relied upon to open and close at the proper periods. From a crude system

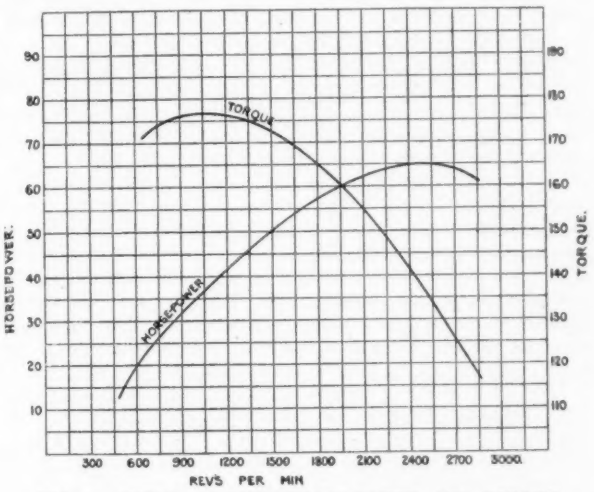


FIG. 1. TYPICAL BRAKE HORSE-POWER AND TORQUE-CURVES OF A MODERN MOTOR-CAR ENGINE

depending largely upon splash, the lubrication of engines has been studied down to the minutest detail, and in the best modern practice the lubrication is by pump, and entirely automatic, which only requires attention at infrequent intervals.

The early engines were only capable of a maximum speed of about 1,500 revolutions per minute, but the torque developed at this speed was practically nil, the torque being a maximum at about 500 revolutions per minute, rapidly dropping off beyond this speed. Today engines will run comfortably under full load at 2,000 revolutions per minute, and may in some cases be accelerated up to over 3,000 revolutions, the maximum horse-power being developed round about 2,500 revolutions per minute.

Fig. 1 gives the typical brake horse-power and torque curves of a modern motor-car engine.

While the weight of the earliest motor-car engine was approximately 50 pounds per horse-power, an average figure for a modern engine without fly-wheel may be given as 8 pounds per brake horse-power, and we may reasonably expect this figure to be reduced to about 5 or 6 pounds in the future.

The question of fuel economy is an important one in any engine intended for automotive purposes not only because it directly affects the running costs, but where considerable distances are to be traversed, the weight of fuel carried and the size and weight of the necessary tanks become considerable.

The following table shows the brake thermal-efficiencies of different types of engines, and from that table it will be seen

that the modern motor-car engine occupies a fairly satisfactory position

COMPARATIVE BRAKE THERMAL-EFFICIENCIES.

Locomotives		4 to 6 per cent.
Steam	Compound (non-condensing) including boiler	8 to 12 ,, ,,
	Compound (condensing)	10 to 16 ,, ,,
	Parson's turbine (including boiler)	15 to 18 ,, ,,
Internal Combustion	Petrol (automobile)	22 to 24 ,, ,,
	Petrol (aero)	26 to 28 ,, ,,
	Coal Gas (stationary)	29 to 31 ,, ,,
	Diesel	33 to 35 ,, ,,
Combined I.C. and Steam	Still Engine (efficiency already obtained)	41 ,, ,,
	Still-Diesel combination (probable efficiency)	44·5 ,, ,,

Owing to the fact that a large amount of reserve power is necessary in a motor-car engine to give rapid acceleration, or to meet the higher tractive effort required for exceptionally heavy-road conditions, or for climbing modern gradients without changing gear, the engine is for the greater part of the time running under considerably less than full load—in fact, for 90 per cent of the time it may be said to be running at from one-third to one-half full load. Obviously, therefore, it is of great importance that it should have a high fuel efficiency under these conditions. In Fig. 2 is shown the fuel-consumption curve of a normal modern motor-car engine running at 1,000 revolutions per minute, from no load up to full load. At full load the efficiency is good, but at half load the fuel consumed per brake horse-power per hour is 25 per cent greater than at full load. At one-third load the conditions are still worse; the consumption is 60 per cent greater per brake horse-power per hour than at full load. In fact, over average running conditions the fuel consumption is 50 per cent greater than the economy attainable at full load. Now, for the conditions I have been describing, the ideal engine should have a fuel-consumption curve somewhat like the dotted line A in the diagram, giving maximum economy from one-third to one-half load, and still a reasonable economy at full load and at no load. Attempts have been made to secure this by providing engines with variable clearance-volumes or by supercharging at full loads, but, so far as I am aware, no conspicuous success has as yet been obtained.

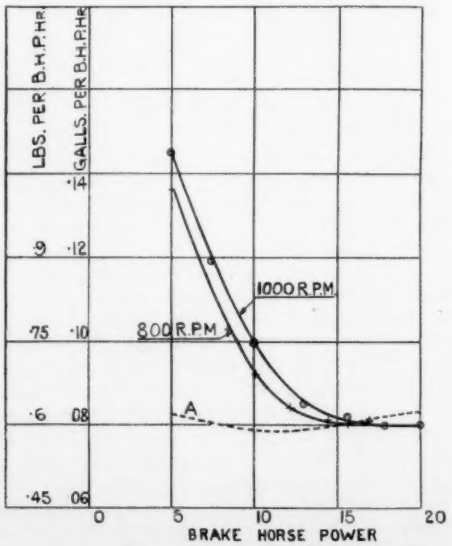


FIG. 2. FUEL CONSUMPTION CURVE OF AN ENGINE RUNNING AT 1,000 REVOLUTIONS PER MINUTE

The present engine is far from being ideal, and leaves much room for improvement, one great shortcoming being that it is not self-starting. The mere fitting of a modern so-called self-starter does not alter the fact that the engine is an inert mass until it is cranked, and this is a serious disability which must be overcome. The ideal engine for vehicle propulsion would be one which was reversible, really self-starting, and having an emergency torque about three or four times the normal, such as, for instance, is obtained in a compound engine by admitting steam to the low pressure cylinder. It goes without saying, of course, that it must be light, simple in design, require next to no attention, be moderate in cost, and reliable and economical in service. The ideal engine which doubtless will be ultimately evolved may quite probably be an entire departure from the internal combustion type as it is known today.

While the question of the speed of a vehicle on the road is not of primary importance, it is perhaps the feature which ranks foremost in the public conception. In this connection, we find a very curious analogy between public opinion as to the safe speed on railways in early days, and public opinion 70 years later in connection with the speed of motor vehicles. When in 1821 the first railway between Liverpool and Manchester was projected by the great engineer, George Stephenson, the fact that he proposed to work the line with an engine running at 12 miles per hour was held up as of itself sufficient to stamp the scheme as a bubble. "Twelve miles an hour!" exclaimed the *Quarterly Review*, "as well trust oneself to be fired off on a Congreve rocket." Experience soon proved, however, that these fears were groundless, but that did not prevent very similar fears being expressed in 1896, and as a result, when motor cars were first legalized on Scottish roads, the speed was limited to 10 miles an hour, although in a few years that was raised to the more reasonable limit of 20 miles an hour, and but for thoughtless and inconsiderate driving in a few isolated cases, this limit might ere now have been considerably increased.

Having these facts in view, it is extremely interesting to note that, in 1894, in the Paris-Rouen race, the average speed of the winning car was 12 miles per hour; whereas, in the Grand Prix of 1914, over a difficult course extending to 466 miles, an average speed of 65 miles per hour was attained; while last spring, on a motor racing track, the mile was covered in 24.02 seconds, representing a speed of 149.8 miles per hour.

In the short space of a quarter of a century the safe speed of passenger transit on ordinary roads has been practically quadrupled. In future, when we have, as we no doubt will have, special motor-vehicle highways with recognized up and down tracks probably running over and under bridges to eliminate the crossing dangers of other intersecting highways, the speed of motor vehicles on these roads will at least equal that of express trains today, and with perfect safety.

Before leaving the question of speed, it should be noted that the question of rapid acceleration is an important one for the motor-car designer. Under ordinary road traffic conditions it is, of course, impossible to maintain a constant velocity from start to finish of the journey. A modern high-grade passenger motor car is capable of acceleration on the level from a speed of 10 miles per hour to a speed of 30 miles per hour in about 10 seconds, and this capacity for rapid acceleration has a very important bearing on the total time required for any given journey. It also has an important psychological effect on the driver, as the knowledge that he can rapidly regain a high speed make him much more willing to reduce the speed to well within safe limits whenever occasion demands.

One of the most notable developments of the past 25 years has been in the materials available for construction. While in the early years of the motor-car industry a good quality of mild steel was practically all that was commercially obtainable, today we have a large choice of alloy steels which has

enabled designers in many cases to cut down the weight of a part to one-third of what it would necessarily have been with the older materials.

The accompanying table shows the enormous advance which has been made in the production of high-grade constructional steels.

Again, in modern engineering, the designer has not only a much better knowledge of the materials he is employing, but he can rely upon their being homogeneous and really having

COMPARATIVE PHYSICAL PROPERTIES OF STEEL.

	Ultimate	Yield.	Elongation in 2 inches.	Reduction of area.
	Tons.	Tons.	Per cent.	Per cent.
Medium carbon steel (normalised) -	30	16	25	45
Bright drawn mild-steel bars. Air Board Specification S1, Part 1	35/42	25	15	40
3 per cent. nickel steel bars (heat treat.). Air Board Specification S8 - -	45	32	24	50
Nickel chrome (heat treated). Air Board Specification S11 - -	55/65	45	18	50
5 per cent. nickel case-hardening steel. Air Board Specification 38 17 -	60	50	13	40
100-ton alloy steel bars. Air Board Specification S18 - -	100	—	8	20
Chrome vanadium spring steel -	115	110	10	—
Special alloy steel for gears, etc. -	134	106	8	15

the physical properties set out in the specification, and, therefore, it is unnecessary to use such generous factors of safety as were usual in the earliest days.

Where the designer is dealing with the problem of motor vehicle or similar structures in which saving of weight is of supreme importance, he must carefully discriminate in the case of each part, and employ only such a factor of safety as is necessary, having in view the point as to whether the structure is only subjected to such a stress as can be accurately estimated, or whether it may be liable to severe overload stresses due to shock. To take a concrete instance, consider the case of a foot-brake lever. Here it is known that the maximum stress which can be imposed is the pressure exerted by the man's foot, and if we take a maximum figure for this it is sufficient to allow a factor of safety of two with respect to the yield point of the material. While in mild steel we dare only stress the part up to 7½ tons per square inch, with 3 per cent nickel steel we can go to 20 tons, and with nickel chrome steel we can go to 30 tons per square inch. On the other hand, there are parts such as axles where the dead-load stresses may only represent as little as 8 per cent of the maximum stresses which may be imposed by exceptionally severe road conditions, and the impossibility of contending with such conditions without the use of these special alloy steels will be readily appreciated.

Prior to the advent of motor engineering, the accepted dimensions and basis of design for machine-cut gearing were such as to have made the motor car an impossible proposition. To give a single instance an electric crane reduction-gear transmitting 30 horse-power at a pitch-line speed of 750 feet per minute, with velocity ratio between the two shafts of three to one—the gears being machine cut of steel—an average size for the teeth was one inch circumferential pitch by 2⅞ inches wide. In a modern motor car gear-box, having machine-cut wheels of case-hardened special alloy steel with the same pitch-line speed transmitting the same power, and with the same speed ratio between the shafts, the following dimensions would be found very ample:—.63 inch circumferential pitch by one inch wide, and the relative weights of the two sets of gears would be in the one case 95 pounds and in the other 11 pounds; in other words, the weight of the motor-car gear is less than 12 per cent of the weight of the electric-crane gear. Where in aircraft design the weight is of supreme importance, by the adoption of still higher-grade materials still greater reduction in weight can be achieved. I do not suggest that all this reduction in weight is due to better materials; probably the two most important factors are the steps that are taken to harden the wearing surfaces of the teeth, so as to carry the enormous loads without deformation or abrasion, and the accuracy with which the teeth are formed and finished, and, in a lesser measure, the precautions which are taken to maintain correct relative position and alinement of the shafts to eliminate deflections and vibrations.

To obtain full advantages of these various alloy steels very special and accurate heat treatment is necessary at various stages of the manufacturing processes. The heat-treating department in a modern motor-car factory is a section of primary importance in charge of a technical expert, and in close touch with the works' laboratory. It embraces a variety of furnaces of different types for normalizing, carbonizing, reheating, and tempering. The trend of design of furnaces would appear to be towards the producer-gas type. The control of the temperature is of vital importance, and in the case of some steels the temperature for a given treatment must be kept within very narrow limits.

The determination of temperature is almost entirely done by means of electrical pyrometers, preferably of the recording type, so that the life history of any batch can be referred to at a subsequent date, if necessary. Batteries of cooling baths are also provided to suit each particular process, and these are carefully maintained at the required temperature.

Fig. 3, which is taken from a paper read recently by Mr. Arthur Stubbs, shows graphically the extreme importance of the correct temperature and the proper methods of cooling if the material is to have the physical properties desired for the particular duty it is called upon to perform. Failure to observe these conditions may produce most disastrous and totally unexpected results. As an instance, similar pieces of nickel chrome steel were reheated to 600° C., the one

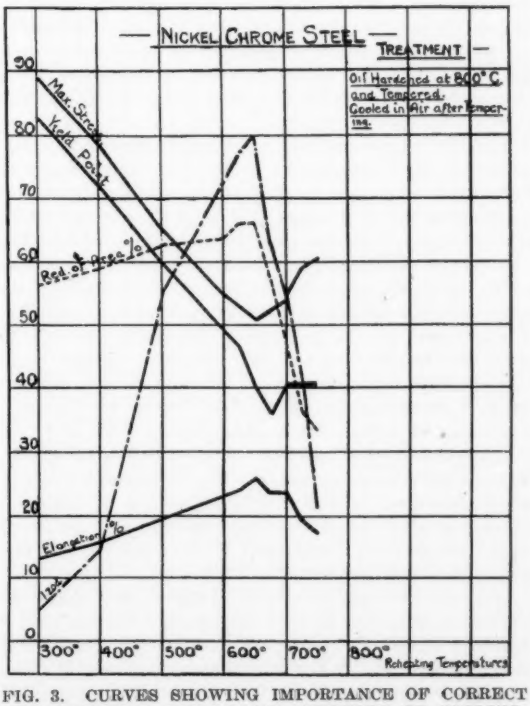


FIG. 3. CURVES SHOWING IMPORTANCE OF CORRECT TEMPERATURE AND PROPER METHODS OF COOLING

water quenched and the other allowed to cool slowly; the sample which was water quenched gave an Izod test of 52 foot-pounds, whereas the slowly-cooled test-piece gave an

Izod test of 1 foot-pound. The greater danger lies in the fact that this extreme brittleness of the slowly-cooled sample would not have been disclosed by an ordinary tensile test.

An extremely useful adjunct to the heat-treating department is the copper-plating shop. By this means the case-hardening effects can be located as desired on machined parts. By proper hardening and tempering one is able to vary the relation between the ultimate tensile strength, the elastic limit, elongation, and reduction in area, and to obtain with certainty the combination most suitable for the purpose in hand.

I cannot leave the subject of materials without referring to aluminum alloys. These are playing an increasingly important part in the construction of motor vehicles and aircraft. These alloys are largely employed in the construction of engine-cases, gear-boxes, etc., and more recently pistons have been largely made of this material. For this latter work they have the two important advantages of lightness and high heat-conductivity. To mention in particular one of these, duralumin is an alloy containing upwards of 90 per cent of aluminum, and has a specific gravity of 2.8 as compared with 7.8 for steel. In the hull construction of the R34 16 tons of duralumin were used. According to the purpose for which it is intended, duralumin can be supplied in qualities ranging from an ultimate tensile strength of 25 tons per square inch with 25 per cent elongation, to 35 tons per square inch with little elongation, the elastic limits being 13.5 and 20 to 27 tons per square inch respectively. The Brinell number for duralumin plates varies from 109 to 174, the higher value being for thin, and consequently hard plates.

Particulars of a new light-piston alloy appeared a few weeks ago in an American technical journal. Its chief constituent is magnesium, which has a specific gravity of 1.74. This new alloy is claimed to be specially suitable for pistons. Its elastic limit is from 5½ to 6½ tons per square inch, and its ultimate tensile strength from 7 to 8½ tons per square inch. It is further claimed to possess a low coefficient of expansion and high heat-conductivity; is easily machined, and less abrasive on the cylinder walls than aluminum. We may look with confidence for still further substantial advances both in alloy steels and light constructional alloys. Progress in the past is only inidcative of what will certainly be achieved in the near future.

Let us attempt to visualize the motor road-vehicle of the future, and the conditions under which it will have to work, say, 20 or 30 years hence. The recent railway strike brought home to the public the capabilities of mechanical transport, and before long the enormous importance to the prosperity of the nation of the highest possible grade of highway will be fully realized. There is probably no other national investment which will ultimately show a more handsome return.

One of the difficult and most important problems to be tackled by civil engineers is the method of constructing highways so that they will require a minimum of upkeep and provide a smooth and clean surface for traffic. The road of the future will be proportionately broad to the traffic it has to carry. It will be so constructed as to be practically dustless, and there will be an absolute prohibition against any other than rubber-tired traffic. Neither horses nor other animals will be permitted on its surface. If they are to be transported over them, it must be in trucks suitable for the purpose, as is done in railway work today. It will then seem just as reasonable to suggest driving a flock of sheep along one of these main highways as it would appear to us today were a farmer suggesting to drive a flock of sheep along a railway line. Traction engines and agricultural implements and such like will not be allowed to destroy the surface as they do at present. Sharp bends will be eliminated, and on main highways few gradients will exceed 1 in 20, and even on subsidiary roads greater gradients than 1 in 10 will probably not be permitted. The surface of these roads will also be maintained at a certain definite standard determined probably by some species of seismograph, and there will be no such thing as the road waves and pot holes with which today we are all so painfully familiar. A private owner will, in fact, have legal redress against the authorities should his vehicle be damaged through defective road surfaces. While discussing the question of roads, it will be interesting to compare, for a moment, the tractive effort necessary under various conditions. The following table gives the tractive effort required in pounds per ton to overcome road resistance:

TRACTIVE EFFORT REQUIRED TO OVERCOME RAIL OR ROAD RESISTANCE.

Railways—	Lbs. per ton
Main-line railways	15
Electric tramways	26-30
Road Surfaces—	
Asphalt on concrete	40-45
Smooth granite setts	50
Tar Macadam, hard	65-70
Clean wood pavement	70
Tar Macadam, muddy and sticky	95
Road metal, partly rolled	120
Tar Macadam, soft and cut up	140
Unrolled road metal	200

This shows conclusively that the question of road surface is of paramount importance and has a direct bearing on the cost of transport, and no effort should be spared to obtain the most efficient road surfaces. When it is borne in mind that a gradient of 1 in 20 necessitates an additional tractive effort of 112 pounds per ton, it becomes abundantly clear that the difference in tractive effort required to haul a rubber-tired vehicle on a first-class road as compared with an electric tramway is so moderate as to be practically negligible. On further reflection it would seem difficult to find any reasonable excuse for the retention of tramway cars, more particularly as they form a most serious obstruction to other traffic in the streets of a town or on a highway, owing to the lack of dirigibility, and the tramway lines form a fruitful source of damage to road surfaces, and constitute also a frequent cause of tire damage and side slips.

When really good roads are an accomplished fact it will no longer be necessary to have a gear-box or its equivalent in motor vehicles, and it is quite possible that it will be unnecessary in the lighter vehicles at least to provide anything in the nature of a differential gear, as the coefficient of friction between the tires and the roadway will not be such as to prevent the slight amount of slipping necessary to take place without damaging the tires.

The gradual improvement in roads will react very materially upon the design and the weight of motor vehicles. At present we are compelled to design vehicles sufficiently strong to withstand the worst conditions under which they may have to work, and in some cases the conditions are very extreme. When one can rely upon reasonably good highways much lighter construction will be possible throughout, and every pound saved in weight reacts through the whole design and throughout the life history and efficiency of the vehicle.

One great problem which demands the closest attention of the engineer is the conservation of our fuel supplies. We cannot go on as we have done in the past. The rate of consumption has been rapidly rising, as has also the cost, and supplies are far from being unlimited. Our duty, therefore, to future generations demands that the most strenuous efforts be made to conserve every ton of fuel, to increase the efficiency of thermal engines, and the various manufacturing processes in order that this end may be attained.

As long ago as 1886, Prof. J. P. Lesley, addressing a meeting of the Institute of Mining Engineers in Pittsburg, said: "I am no geologist if it be true that the manufacture of oil in the laboratory of Nature is still going on at the hundredth or the thousandth part of the rate of its exhaustion. And

the science of geology may as well be abandoned as a guide if events prove that such a production of oil in western Pennsylvania as our statistics exhibit can continue for successive generations. It cannot be. There is a limited amount. Our children will merely and with difficulty drain the dregs."

It should be clearly borne in mind that we have been in the past, and are at present, living upon capital; this, as every business man knows, is a prodigal policy, and sooner or later will lead to bankruptcy. In other words, we must live on revenue—that is to say, we must year by year obtain in some manner or other our annual supply of fuel either from agriculture or some other natural source of production. Here it is appropriate that I should make a brief reference to the possibilities of alcohol as a fuel and the report recently issued by the Government Alcohol Committee. With the desire of fostering home porduction and fuel for motor vehicles, France has for years past devoted a large amount of attention to the question of running internal combustion engines on alcohol, with considerable success. In the French War Office trials, carried out in 1910, the following very interesting results were obtained:

Petrol (gasoline).....53.2 gross ton-miles per gallon.
Alcohol fuel .....46.3 gross ton-miles per gallon.
Benzol .....57.1 gross ton-miles per gallon.

The alcohol fuel was a mixture consisting approximately of 50 per cent alcohol, 35 per cent benzol, and 15 per cent petrol.

Taking alcohol at 1s. 3d., benzol at 1s. 10d., and gasoline at 1s. 11½d. per gallon, the cost per ton-mile works out at .45d. for gasoline, .412d. for alcohol fuel, and .385 d. for benzol.

It has been clearly demonstrated that alcohol alone, or a mixture of alcohol and gasoline or similar fuels are quite suitable for the propulsion of motor vehicles, and there seems to be little doubt that alcohol will be one of the most important fuels in the future. Its merits are summarized in the following sentence taken from the British Government Committee's report:

"The outstanding and fundamental attraction of alcohol motor fuel as a substitute for any fuel necessarily derived from coal or oil deposits lies in the fact that, on account of its chief sources being found in the vegetable world, supplies of raw material for its manufacture are being continuously renewed, and are susceptible of great expansion without encroachment upon food supplies."

While the prospect of commercial production in Great Britain is not encouraging, there is every possibility that the necessary supplies of alcohol fuel could be produced within the British Empire, the raw material being obtained from tropical countries. The vegetable materials from which alcohol may be produced are so varied and widespread that there would appear to be almost no limit to supplies. There are sugar-containing products, such as molasses, large quantities of which are at present running to waste; starch-containing products, such as cereals, potatoes, etc.; and cellulose-containing products such as wood pulp.

Dr. Ormandy, in a paper read in 1913, instanced a plant intended for British Nyassaland capable of producing 600 gallons of alcohol per week from maize. The cost of the raw material only amounted to 3d. per gallon of alcohol. The other charges he estimated at 6d. per gallon, making a total cost of 9d. per gallon at the distillery. This, however, as he pointed out, is a very small plant, and from the figures given by other authorities there seems to be little doubt that alcohol can be produced at from 5d. to 6d. per gallon at the distillery. In the recent Government Alcohol Committee's Report there is indicated a very promising source—namely, flowers of the mahua tree. These the committee stated could be cultivated and delivered at the local distillery at 30s. per ton, which would represent a raw material cost of 4d per gallon. Given, therefore, reasonable excise regulations, which will no doubt come in time, there seems to be no reason why denatured alcohol fuel should not be delivered to the consumer at about 1s. 3d. per gallon.

The following table shows the comparative properties of denatured alcohol, petrol (gasoline), and paraffin (kerosene), and the cost per brake horse-power per hour with these fuels:

COST PER B.H.P. PER HOUR ON VARIOUS FUELS.

Fuel.	B.Th.U's. per lb.	Brake Thermal Efficiency.	Lbs. per B.H.P. per hour.	Specific Gravity.	Gallons per B.H.P. per hour.	Price per gallon.	Cost per B.H.P. per hour.
		Per cent.					
Denatured Alcohol	11,000	30	·77	·825	·093	1/3	1·40d.
Petrol -	19,000	23	·58	·780	·075	1/11½	1·76d.
Paraffin -	20,000	20	·64	·810	·079	1/6	1·42d.

Steps must also be taken to fully utilize our natural sources of energy, such as waterfalls. We may even be compelled to devise satisfactory ways and means of obtaining mechanical energy from such sources as solar heat, wind, and tides.

Perhaps the most interesting field of application of the internal combustion engine, and certainly the most romantic, is in the realm of flight. From the earliest ages it has been man's ambition to conquer the air, and one can scarcely realize that little more than a decade has elapsed since the brothers Wilbur ond Orville Wright first accomplished a flight in a machine heavier than air driven by a gasoline engine. In this field, particularly during the war, development of design has been astonishingly rapid, and one might say with truth that the results achieved have been almost miraculous. While the Wright brothers began with an engine developing 15 horse-power, airplanes are being constructed today with one or more engines each developing 400 or 500 horse-power. One of the most successful engines of modern design develops 450 horse-power, and only weighs 662 pounds, or rather less than 1½ pounds per horse-power. Even when an engineer accustomed to motor-vehicle practice. which is thought to combine maximum lightness consistent with safety, is first brought into contact with these latter-day aero engines, he stands aghast to see how fine the limits of weight have been cut. It was stated in a recent publication that the weight-carrying capacity of a modern airplane is about 33 per cent of the total weight. It is not unreasonable to assume that in the next few years this percentage should be raised to at least 50, and upon this assumption it ought then to be possible to construct an airplane capable of carrying one man and sufficient fuel for a short journey, having a total weight of 150 pounds. The engine would probably be about 20 horse-power, of the air-cooled type, weighing not more than 20 pounds. A few years hence, therefore, we may see practical machines offered on the market enabling a man to fly from point to point with as great ease as he would cover the distance on a motorcycle today. Great progress will doubtless be made in the construction of larger airplanes and in their commercial use, though it must be borne in mind that the manipulation of these machines will always require a much higher degree of physical efficiency than is necessary for the control of vehicles running on land or water, as the landing of an airplane must always call for a cool head and sound judgment. Simultaneously with the development of the heavier-than-air machine, great progress has been made in the construction of lighter-than-air craft, and I need only refer to the magnificent feat of the Clyde-built airship R34 in crossing and recrossing the Atlantic a few months ago. It may safely be said that the rate of evolution of aircraft will largely depend upon the progress that is made in evolving new and improved prime movers. The field offered to the young engineer is illimitable.

One of the most impressive illustrations of the modern development of the light internal-combustion engine is the extent to which it was used, and the part it played, in the great war. In the air the gasoline engine alone served for the propulsion of airships, airplanes, and flying boats. On the land it was principally used for the propulsion of either passenger- or goods-carrying vehicles or engines of war, such as tanks; and also for a large number of other purposes where a light portable prime-mover was necessary. On the sea it was utilized for the propulsion of motor boats and various small craft, as well as for auxiliary purposes. At the conclusion of hostilities the British War Department had 62,000 motor lorries, 28,000 cars, and 33,000 motor cycles.

By the courtesy of the Ministry of Munitions I am able to give a statement of the total horse-power represented by the output of internal combustion engines by British manufacturers during the war.

The table is divided into three sections—namely, aero engines, mechanical transport engines, and tank engines; of the former the total production during the war amounted to the enormous figure of 7,094,000 horse-power. Dealing with mechanical transport engines, the table does not give the figures for the years 1914 and 1915, but these aggregate about three-quarters of a million horse-power, and, therefore, the total brake horse-power of mechanical transport engines produced for war purposes was 2,232,000. For tank engines the total was 340,000 horse-power, making a grand total for all classes of 9,666,000 horse-power. A prime mover that has so

ENGINES PRODUCED 1914-1918 IN TERMS OF HORSE-POWER.

Type.	Aug.-Dec. 1914.	1915.	1916.	1917.	1918.	Total.
Aero engines	12,000	195,000	771,000	1,973,000	4,143,000	7,094,000
Mechanical transport engines			137,000*	683,000	662,000	1,482,000
Tank engines	—	—	16,000	133,000	191,000	340,000
	12,000	195,000	924,000	2,789,000	4,996,000	8,916,000

* Four months, September to December, only.

wide and general an application merits the closets attention, and no effort should be spared to improve it.

While there has been great progress in the last 25 years in the constructional materials available for the engineer, there has also been a great development in machine-tool practice generally, and especially in the evolution of tools for the production of parts in quantity in a cheap and efficient manner, and of such high-grade accuracy as to be interchangeable. Time only permits a very brief reference to this interesting subject, but perhaps the advance made in automatic grinding-machinery is one of the most interesting developments. Not only has the grinding machine made it possible to produce with ease complicated parts such as multiple-throw crank shafts with an accuracy unapproachable even by a skilled turner, but also at far lower cost. In the process of case-hardening, a certain amount of permanent distortion inevitably takes place, and in no other way could this be rectified than by the use of automatic grinding-machines. Brought to a high state of perfection, they can deal with practically any form of surface, flat, circular, internal or external, or of irregular shape, such as cams for operating inlet and exhaust valves. Such cams can be produced commercially to a limit of accuracy of 1/1000 inch. In fact, where drop forgings are used it is no uncommon practice to dispense with the lathe entirely, and to machine and finish such parts as crank shafts and camshafts right from the forging on grinding-machines. Considerable success has also been achieved in automatic grinding-machines to rectify the teeth of hardened gear-wheels, where the slight distortion that is almost inevitable under heat treatment would otherwise set up undesirable noise.

In motor car work the diameter of the shafts is so small in proportion to the torque transmitted that the old-fashioned methods of keying are insufficient. The best modern practice is to machine 6, 8 or more key-ways equally spaced on the shaft, and these, after hardening, can be ground to accurate dimensions in suitable automatic grinding-machines.

Broaching or drifting machines are being increasingly used for producing all shapes, or holes, such as the castellated holes in the bosses of wheel parts to be mounted on a castellated shaft such as I have been describing.

I cannot omit a reference to the great advance which has been made by the introduction of what is known as high-speed steel for cutting tools. As the accompanying table shows,

	Medium steel forgings.	Hard steel forgings.	Hard cast iron.
	Feet per min.	Feet per min.	Feet per min.
Carbon tool steel, 1894	16	6	15′ 6″
High-speed steel, 1906	99	41·5	52′ 0″
Increase	6 times.	7 times.	3 times.

it permitted cutting speeds to be very substantially increased, and it enabled much heavier cuts to be taken—two facts which very soon led to the complete redesign of machine tools. Much stiffer tools were required, tools running at a higher speed and of much more rigid design, so that full advantage could be taken of the new steels.

Wherever a highly-specialized piece of machinery is to be produced in quantity, the aim of the engineer must be to confine skilled labor to the tool room, and in the factory proper the tools must be as nearly automatic as possible, and should also be, as far as practicable, single-purpose tools so as to avoid all unnecessary complication in their construction. They should, in fact, eliminate the necessity for jigs.

It must ever be the engineer's aim to cut down the time required for the production of any given part to a minimum; therefore, as far as possible, similar operations on a part should proceed simultaneously. For instance, multiple head milling-machines are now built which will surface three or four faces on, say, a cylinder block simultaneously at one setting. Again, in a succeeding operation it may be necessary to drill upwards of 50 holes in the said cylinder block distributed on three or four surfaces. Machines are now constructed which will bore all these holes simultaneously at one setting. This indicates the direction in which evolution is tending, and wherever the quantities to be produced warrant the expense, it is the correct policy to adopt. It is in this connection that standardization of parts is not only of immense value to the engineer, but equally so to the benefit of the community at large. A policy of standardization must, however, be pursued with caution, for there is a tendency when standards are fixed to adhere slavishly to them with the inevitable result that progress is thwarted, and new and improved methods are thereby rendered more difficult of introduction.

While not belittling for a moment what has been achieved, the product of the automatic tool still, as a rule, leaves something to be desired. To be entirely satisfactory it must finish off the article with all necessary fillets, male and female, and all rags of every kind must be automatically removed so that the part passes on to the finished parts' store, and ultimately to the erector, then into its place without any file, reamer, or scraper touching any portion of it. It is only the country whose engineering factories adopt the higher standards that will be able to compete successfully in the markets of the world.

FIG. 1. JEFFREY PIT CAR LOADER IN OPERATION IN A COAL MINE

Loading Machines for Underground Use*

Their Efficiency in Reducing Mucking Charges

By A. M. Gow

THE desirability has long been recognized of some machine that will reduce the arduous labor or "mucking," or shoveling ore or coal into tram cars underground. Many attempts have been made to produce such machines. Machinery has been introduced into almost all other operations of mining to increase the tons per man and reduce operating cost. Even the books are kept and the bills made out by machine; but the No. 2 shovel still holds its own. It will have to give way, however, for the insistent demand for an underground loader, and the efforts that are being made to produce it cannot fail to bring about a certain degree of success.

It is not to be expected that one design of machine will meet all requirements, because the underground conditions as to head-room, tonnage, and character of material vary between extremely wide limits. A machine admirably adapted for work in one mine might prove utterly useless in another. The conditions in one mine might warrant an investment wholly prohibitive elsewhere. A machine designed to handle a large tonnage in a low coal seam would in all probability prove inoperative in an iron ore mine on the Mesabi Range. Compressed air may be the most suitable source of power in one district and electricity in another. Consequently, there is room for machines of several types differing from each other not only in detail of design but in their fundamental principles of operation. These fundamental principles have already been pretty well disclosed and incorporated in many machines, many of which have been of a more or less experimental nature.

NO ONE MACHINE MEETS ALL CONDITIONS.

The ambitious inventor would do well to examine the files of the Patent Office and familiarize himself with the state of the art and also learn as much as he can from the successes and failures of other inventors. It is usually a good plan to begin where the other fellow left off. Possibly some genius may appear with some new and revolutionary idea, but that seems hardly probable. Success is to be looked for in the proper mechanical design and proportion of parts and adaption to a given set of conditions. No one machine will meet them all.

It is useless to attempt to draw a general specification for an underground loader or to make an accurate statement as to the requirements it shall fill, except in the most general terms. Of course, it should be low in first cost, but at the present time it is almost impossible to hazard a guess as to what is the maximum price an operator can afford to pay. "Low first cost" in one place might be ruinously high in another. Simplicity of mechanism and fewness of parts are of course desirable, particularly in ore mines where the stuff handled is fine and as abrasive as emery. Inasmuch as the operators have little mechanical skill and training, the machine should be as nearly "fool proof" as possible. When the machine fails the whole mining program is liable to derangement; there is no place to put the machine and facilities for repairing it are poor. But such considerations should not be given undue emphasis. Machines on the surface break down and wear out, but operators do not go without them on that account. Furthermore, operators must not expect too much at this time. After the designer has done all he can, the machine must be really developed underground. And here the manufacturer and the user should coöperate to their mutual advantage.

There is no doubt about the demand for such machines, and the increasing wage scale and the scarcity of men able and willing to "muck" make the demand more acute. Some operators hold that, even if machines should not reduce the cost of production, there would be other gains not shown upon the cost sheet that would make the use of machines well worth while. If, in addition to doing the work, machines will reduce the cost of production, taking into consideration investment, maintenance, and depreciation, so much the better.

TIME CONSUMED IN MUCKING.

Time studies made underground in mines when a number of operations constitute a cycle and result in the production of a certain tonnage usually show that the most promising field

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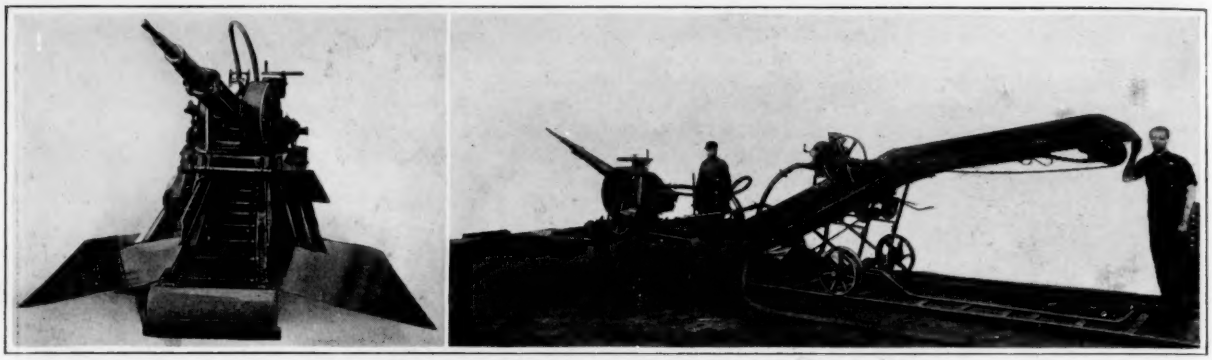


FIGS. 2 AND 3. INGERSOLL-RAND ENTRY CUTTER AND LOADER.

for saving labor is upon that item where labor is most largely expended, namely "mucking." Though, of course, the time consumed in the different operations varies greatly in different mines, take it by and large in metal mines, it appears that "mucking" consumes 35 to 40 per cent of the time, the remainder being distributed over such items as blasting, blowing out smoke, tramming, trimming, timbering, drilling, track laying, and so forth, in varying percentages. Evidently the place to increase efficiency and tons per man is upon the shoveling of the dirt after it has been broken down.

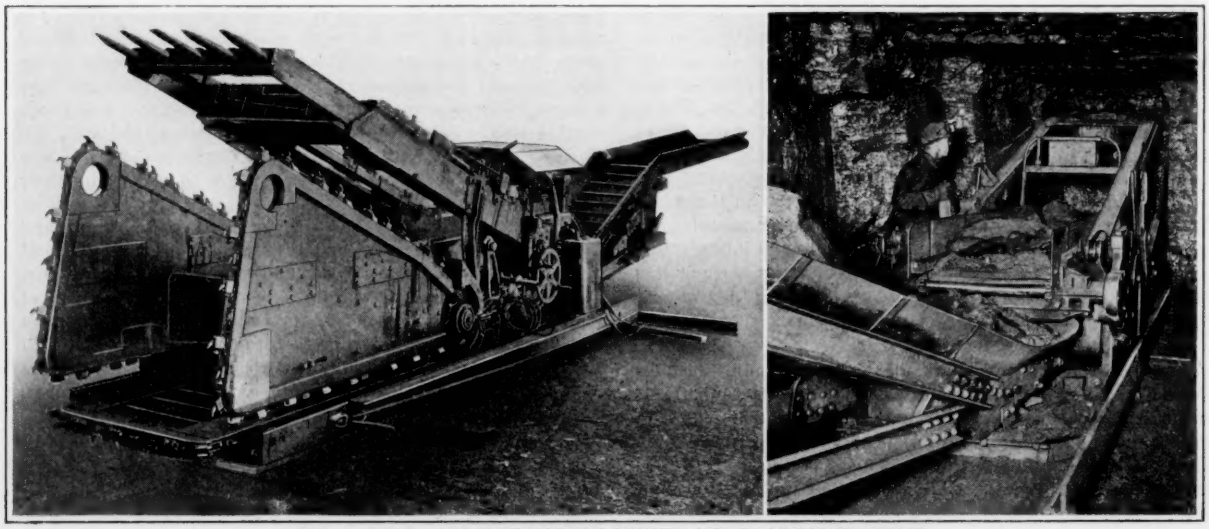
It would appear that great activity has been shown in the coal-mining industry to produce such machines than has been shown in that of metal mining. The tonnage and the character of the material are probably more favorable in coal than in metal mines. But each has its own difficulties. In no place does the problem seem an easy one.

Shoveling into tram cars really comprises two operations: digging the loose material and elevating it into the cars. Inventors and mechanics working along different lines have produced distinct types of machines, varying between wide limits in cost and weight and ranging in all degrees from extreme simplicity to great complexity. An attempt is here made to group these various machines according to their fundamental principles. Such grouping or classification is necessarily inexact, because the types overlap each other and some machines might reasonably appear in two groups. The purpose, however, is to show what has been tried from the mechanical standpoint. The economical results and effects upon the cost sheet will not be treated here. Such statements are liable to be very misleading, and results obtained with the same machine may differ greatly at different times.

It has occurred to many persons that the problem could be at least partially solved by a machine that would simply be a loader and not a digger, the idea being that the heavy labor comes in in raising the loaded shovel to the top of the tram car. Probably the simplest form in which the idea appears is in the Jeffrey Pit Car Loader shown in Fig. 1. This machine consists of a motor-driven belt conveyor set upon an incline, passing over head and tail pulleys as small in diameter as practicable. The ore or coal is shoveled by hand upon the conveyor at its lower end, and elevated into the tram car. This machine is not upon its own wheels, but is moved through the drifts on a timber truck and set in any position desired. Several years ago the Cleveland-Cliffs Iron Co. built such an elevator and mounted it upon wheels.

Inasmuch as a surface wagon loader along similar lines is in very general use, it would seem that there might be a field for this type of machine if properly designed to meet underground conditions. But apparently the feeling among mining men is that if the material has to be shoveled anyhow it might just as well be shoveled into the car and be done with it, and to fill the bill an underground loader must dig as well as load.

It has been suggested time and again that a modification of the idea almost universally used on concrete mixers could be used for underground loading. Sand, cement, and aggregate are deposited upon a pan, and then, by power means, the pan is elevated to discharge into the drum. If a similar pan were adopted to discharge into a tram car, the shoveling upon the pan would be mostly on the level, large chunks would not have to be lifted by hand, and a fair proportion of the dirt could be picked off the pile right on the pan. By



FIGS. 4 AND 5. JEFFREY-MORGAN MINING AND LOADING MACHINE

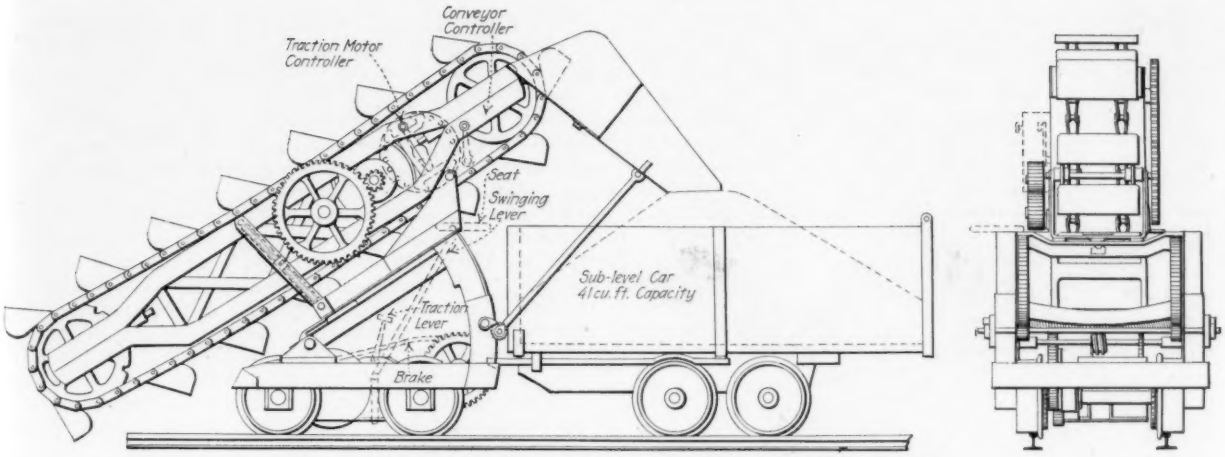


FIG. 6. McQUEEN LOADER, BUILT BY THE OLIVER IRON MINING CO.

means of a wire rope and a small winding drum, the pan could be elevated through simple guides of structural steel so bent at the top as to dump the pan into the car. In the absence of power, the drum could be turned by hand like a winch. So far as I know, this idea, although sketched in several forms, has not been reduced to practice. This proposal meets with the same objection. The machine does not dig. It only elevates. It does but half the work. If the capacity of the machine to load is limited by the shoveling capacity of the men, it is not worth while. Whether or not this position is well taken, the fact remains that although proposed and tried out some years ago, machines that simply elevate and do not dig have not come into extensive use in mining operations.

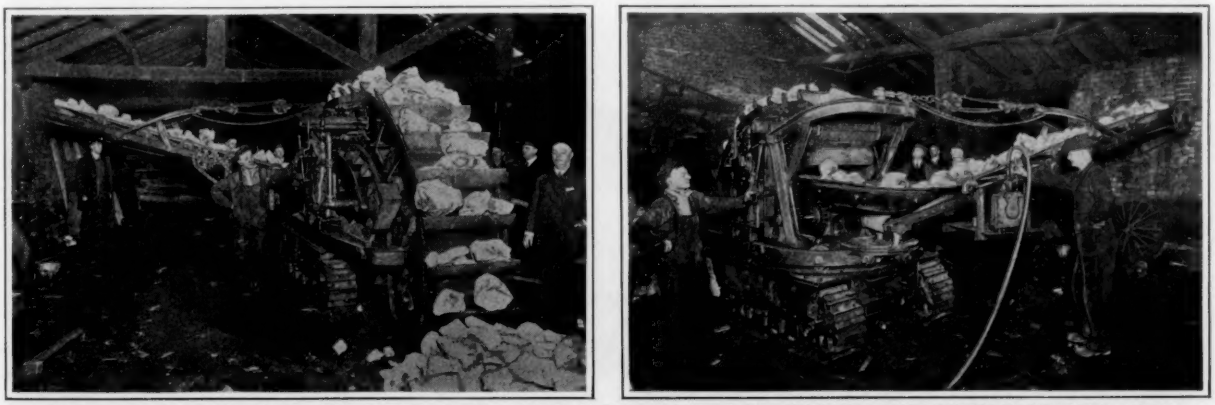
To avoid shoveling upon the conveyor the Ingersoll-Rand Co. about ten years ago developed a combination of coal puncher and elevator shown in Figs. 2 and 3. A powerful puncher is situated on a carriage over the low end of a flat conveyor. The puncher is capable of vertical and lateral movement. The first operation is to undercut the seam, then move the low end of the conveyor as far forward as possible and break the coal down upon the conveyor. Obviously, such a machine could be used only in material like coal, soft enough to be mined without blasting. In fact, one strong claim for the machine was that it dispensed with explosives. Though it has been used successfully in certain coal mines, it has not come into general use. In iron mines it, of course, is out of the question.

The same fundamental idea of breaking the coal down so as to fall upon an elevator was worked out in a very elaborate manner by the Jeffrey Manufacturing Co. It was brought out in 1913 and is called the Jeffrey-Morgan Mining and Loading Machine. It is designed for thick coal seams. It is shown in Figs. 4 and 5. The undercutting and vertical shearing are done by cutting chains, and a series of heavy reciprocating picks break down the coal upon the conveyor underneath, which discharges upon a second conveyor, which in turn, delivers into the car. This machine, though tried out thoroughly, has not proved popular. The number of movable parts, its complexity, and high cost seem to be against its general adoption, even in mines working seams of sufficient depth to permit of its operation. It can operate only in material so soft that blasting is not required.

As was to be expected, the idea of a bucket elevator has appealed to a number of ambitious inventors. On the surface, bucket elevators dig from a boot, elevate, and discharge. Why not do the same underground? Such a machine must be able to hold itself against the pile of dirt in order to make the bucket fill. Under its own power it must have forward and backward motion, and, in addition, a certain amount of radial motion to cover the width of the breast. Twenty-odd years ago such a machine was built at the shops of the Minnesota Iron Co., intended for use at the Fayal mine. It was a heavy, clumsy affair, and did not prove at all satisfactory. No photographs or drawing are available.

A machine along similar lines, though much more carefully designed, was built about five years ago in the Hibbing shops of the Oliver Iron Mining Co. It was designed by H. R. McQueen. Fig. 6 reduced from the general drawing, shows the arrangement. It gave good results so far as it was tried, but was not in service long enough to really determine its limitations. Unfortunately it was destroyed in a fire without having had a fair chance to show what it could do.

A very ambitious attempt along the bucket-elevator line is shown in Figs. 7 and 8. This machine, known as the Jackson shovel, has been built in five sizes. Obviously, the machine here shown was not designed to meet the underground con-



FIGS. 7 AND 8. FRONT AND REAR VIEWS OF THE JACKSON SHOVEL WHICH EMBODIES THE BUCKET-ELEVATOR IDEA

ditions of the average mine. A much smaller model, only 5 ft. 6 in. high, was designed for mining use. I am not informed as to what is the status of this machine today, or whether it was ever given a thorough tryout underground.

The latest aspirant for public favor of the bucket-elevator type is known as the McDermott Continuous Twin Scoop Leader and is put on the market by the Wellman-Seaver-Morgan Co. Fig. 9 gives a clear conception of it. From the

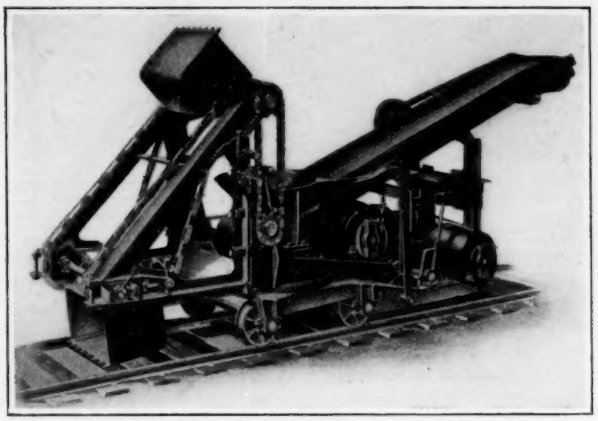


FIG. 9. McDERMOTT CONTINUOUS TWIN SCOOP LOADER

advertising literature the following description is taken: "The material is taken up by scoops or buckets on an endless chain, elevated and dropped into a hopper, which feeds to a conveyor belt, which, in turn, loads into a car. The scooping mechanism is so pivoted that it can dig as well to the side as to the front of the machine. The ore, however, being delivered to the conveyor through the hopper, reaches the car behind the loader no matter at what angle the scoop is loading. The dimensions are: Length, 15 ft. 9 in.; height, 6 ft. 7½ in.; width, 4 ft. 0 in.; weight, 8,000 lb." The averaging loading capacity is given as 45 tons per hour. It is reported as giving excellent results in at least one iron mine in Michigan.

From the mechanical standpoint, machines of this type are subject to the criticism that, inasmuch as iron ore is very gritty, the many movable parts, links, pins, and other members, incident to the use of a chain belt will be subject to excessive wear. How serious this objection is remains to be seen. It undoubtedly has less weight applied to machines for use in coal mines than in iron mines. Machines will wear out, and repairs and maintenance are an offset to the advantage and economies effected by any kind of machine loader.

Another type of machine comprises a reciprocating digging element at the front that discharges the material upon a conveyor that delivers it into a tram car in the rear. Two machines, the Myers-Whaley, built by the Myers-Whaley Co., and the Halby, built by the Lake Shore Engine Works, Marquette, Mich., incorporate the idea. These are beyond the experimental stage, having gone through several years of experience and trial and the strengthening of weak places. They show careful design, and under certain conditions of operation have proved entirely successful. The Halby has been pretty thoroughly tried out in the iron mines of Michigan, and, though it proved entirely operative so far as digging and loading was concerned, it has not met with favor sufficient to warrant its general introduction as a substitute for hand mucking. The size, weight, first cost, and mechanism of these machines, in the opinion of the operators of iron mines, leave them out of the running in competition with hand labor. The Myers-Whaley machine is shown in Fig. 10 and the Halby machine in Fig. 11. Both machines are built in different sizes. The dimensions of the No. 4 Myers-Whaley are given as length, 26 ft. 0 in.; height, 4 ft. 6 in.; weight, 18,000 lb. The No. 2 model has a length of 21 ft. 0 in.; height, 3 ft. 10 in.; weight, 9,000 lb. The latest model of the Halby, T-700, is 23 ft. 4 in. over all, 4 ft. 6 in. high, and 4 ft. 8½ in. wide.

In the Pennsylvania coal regions the Halby has been installed in several mines and is reported as giving most excellent results. A capacity of one ton a minute is easily obtained. In fact the tonnage is limited far more by the difficulty of getting cars than by the capacity of the machine to dig and load. In this respect the loading machine is ahead of the management, and if it is the intention to use machines the mine should be laid out accordingly.

Another machine which properly belongs in this group, but differs radically in mechanical construction, was built by Messrs. Billings & Middlemiss and tried out at the Morton mine, in the Mesabi Range. It is shown in Fig. 12. The digging element in this case is a large, powerful hoe, having a forward and backward motion, adapted to hoe the ore upon an apron. From the apron the ore is discharged upon a belt conveyor and thence into the tram car. The belt conveyor was operated by an air engine, and the movement of the hoe, the swinging motion to enable the hoe to cover the width of the breast and the tilting motion of the conveyor, was obtained from direct-acting air cylinders. Underground at the Morton mine the machine was reported to be digging and loading successfully, but apparently it never got beyond the development stage, and so far as I can learn it is not being exploited today.

Where stopes are high enough and tonnage is large enough, there is no reason why revolving motor-driven machines of the steam-shovel type should not be operated underground. It would seem that a small revolving shovel would go a long way to solve the problem in many mines, and, as would be expected, the idea has been mechanized along several lines. The fundamental conception is that of a shovel or dipper filled by forcing it into the pile, then raised, revolved 180 degrees, the dipper door tripped, and the load dropped into the car.

The Thew Automatic Shovel Co., of Lorain, Ohio, build a

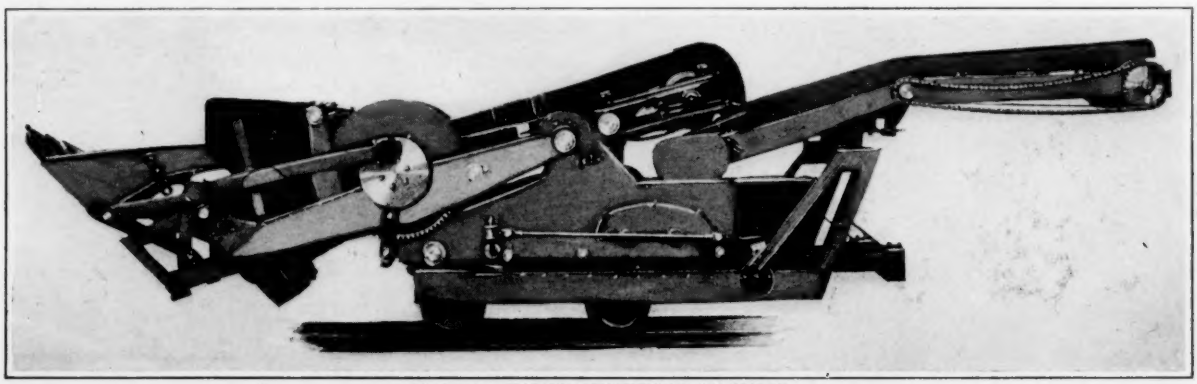


FIG. 11. HALBY SHOVELING MACHINE

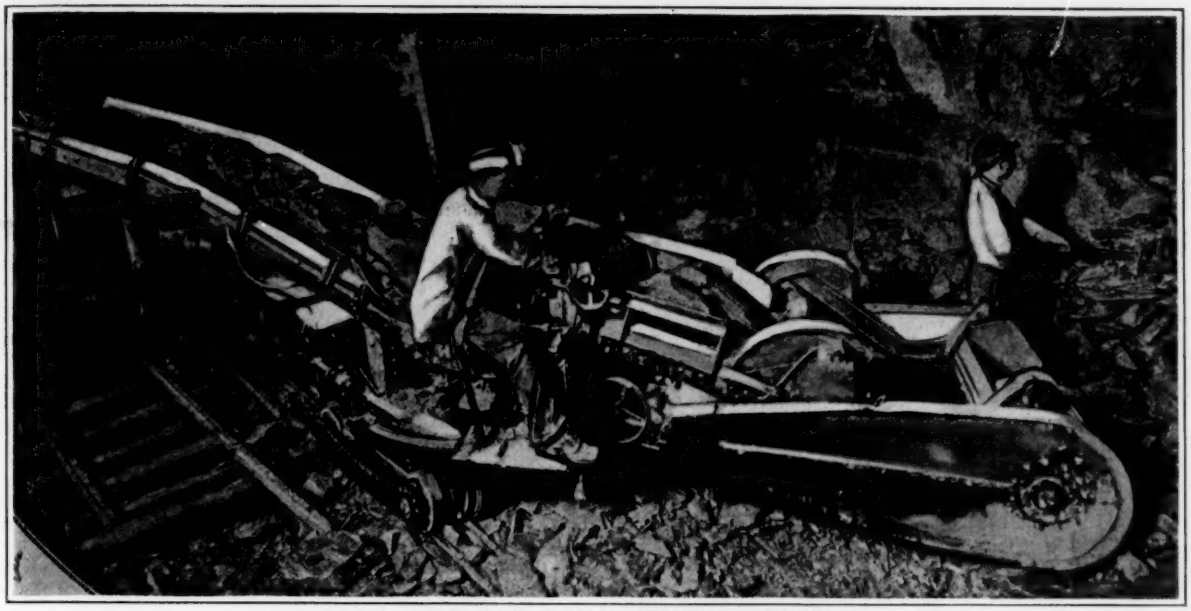


FIG. 11. THE MYERS-WHALEY SHOVEL IN OPERATION

small, motor-driven shovel especially designed for underground work. Though it is a small machine as steam shovels go, it is quite large as an underground loader. It is shown in Fig. 13. The dimensions given are over-all height, 9 ft. 0 in. to 12 ft. 0 in., over-all length about 25 ft. 0 in. One twenty-horsepower motor by means of friction clutches furnishes power for the operations of hoisting, crowding, swinging, and propelling. Where head-room will permit and tonnage warrant, there can be little question as to the operativeness of this machine.

A large builder of mining machinery is now engaged upon the development of a machine of this general type designed to work in low coal seams. A centrally located hydraulic jack, like a large drill column, holds the machine in place between floor and roof. A horizontally operating dipper stick, carrying a very flat dipper, is adapted to revolve around the central column. The dipper having been filled by forcing it horizontally under the pile, is raised, swung around over the car, and discharged by means of a pusher. Where the roof is low and the room is large the machine would seem to present many possibilities. It is not yet beyond the developmental stage, and the builders request that no photographs be published at present.

For several years Captain Samuel Hoar, a mining man of Virginia, Minn., has worked to produce a revolving shovel small enough and strong enough, sufficiently simple and "fool proof," to meet the demand upon the iron ranges of Minnesota and Michigan. The results of his efforts are embodied in the Hoar Loader, as manufactured by the National Iron Works. It is shown in Figs. 14 and 15. Upon a truck is mounted a turntable, carrying the "power unit." This "unit" consists of three reversible air engines, each controlling one motion of the machine. The dipper first moves forward horizontally by the action of one engine. It is then swung into the horizontal position by the action of another. The third then rotates the turntable, until the dipper is over the tram car, when the operator trips the dipper door by hand. The operator rides the machine and handles three levers, one to each engine, in the forward or backward position. Obviously, the machine can be equipped with motors instead of air engines if desired. The machine can work in a drift 6 ft. 6 in. high by 9 ft. 0 in. wide. The movable parts are well covered and protected from dirt and water. This machine seems to be growing in favor. Entirely successful operations from the cost sheet side are reported from a number of iron mines. Though, no doubt, the machine will be improved as experience dictates, nevertheless it is past the experimental stage. Particularly good reports are heard from its operation in rock drifts where mucking is specially laborious.

All the machines thus far described are open to the criticism that they comprise constantly moving parts, such as motors, chains, elevators, and so forth, involving more or less complexity and wear. As said before, just how much weight should be given to this criticism is problematical. But there is an entirely different type of machine to which it is not applicable at all, for the movements are intermittent and obtained by means of direct-acting air cylinders. A dipper is loaded by being pushed directly into the pile. It is then swung directly upward, over and backward to a dumping position, and discharges into a tram car without the intervention of any conveying mechanism.

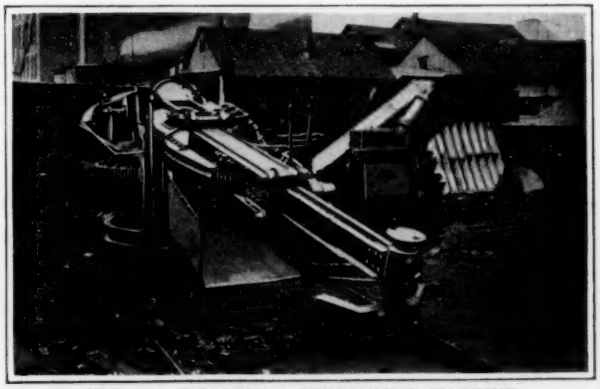


FIG. 12. BILLINGS & MIDDLEMISS MACHINE

The machine is capable of sufficient radial movement to enable it to cover a breast nine or ten feet wide or four and a half to five feet each side of the center line. The machine is not self-propelled, as it is argued that the idea lends itself to so light a mechanical construction that it can be readily pushed through a drift by hand and that self-propulsion involves mechanism not worth while. The radial movement, too, is accomplished by hand, but the other movements are controlled by direct-acting air cylinders. For a given amount of power expenditure there is no question that electricity is

cheaper than air. But it is argued that air is always present to operate power drills, and not in use for that purpose when loading is being done. Therefore, air is the logical power to drive the machine. The argument would seem to have considerable weight, especially in levels and in places where it is not desirable to put in electricity for haulage. Two machines of this type have been designed, the Middlemiss and the

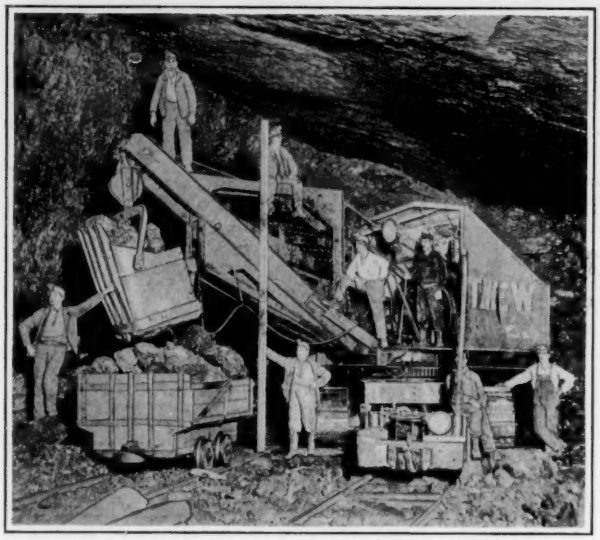


FIG. 13. THEW ELECTRICALLY-DRIVEN SHOVEL UNDERGROUND

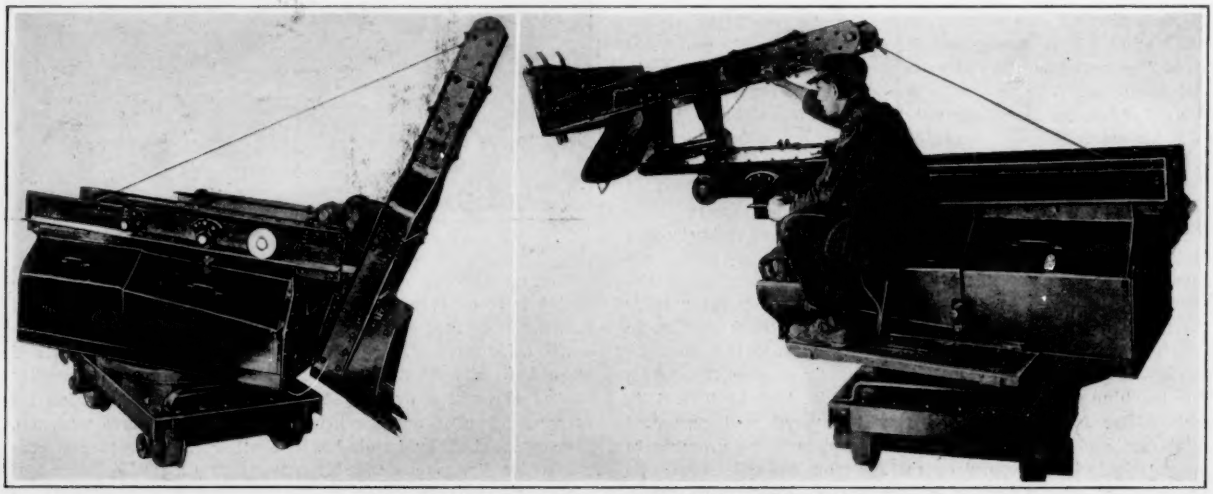
Armstrong. Though several Middlemiss machines have been built and operated underground, it is still in the development stage and has not reached commercial form. Figs. 16, 17 and 18 showed one model in three different positions.

The dipper is secured to the end of a piston rod and driven into the pile by a direct-acting air cylinder. Upon reaching the end of the stroke, the air is reversed, and the backward movement of the piston in the cylinder rotates both cylinder and dipper to the dumping position. The velocity of the dipper at the end of its backward strokes determines how far the dirt will be thrown, and this velocity is controlled by a cataract cylinder. The dipper then returns to its first position by gravity, ready to repeat the cycle. Many troubles were experienced with the one machine with which I am familiar, but they did not appear to be insurmountable and I am advised that an improved design will be tried out soon, in which it is hoped that the troubles will be overcome.

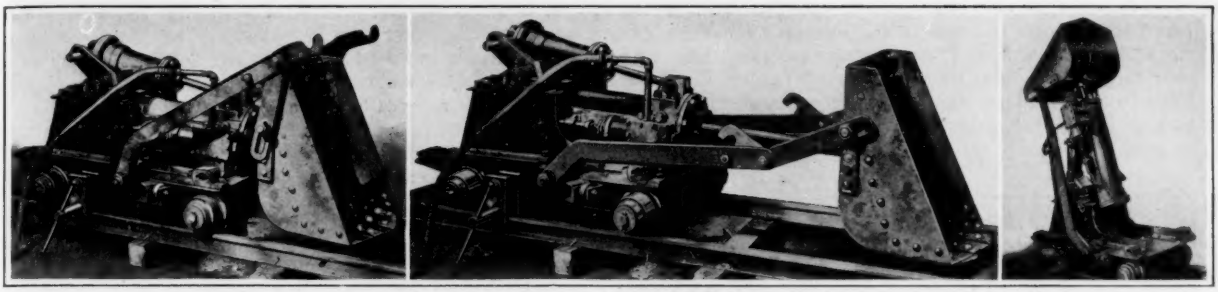
The Armstrong Loader is the result of several years' hard and persistent work of Frank Armstrong, mechanical engineer of the Penn Mining Co., and manufactured by the Lake Superior Loader Corporation. It is shown in Figs. 19 and 20. It differs widely in mechanical detail from the Middlemiss, and has little in common with it except the fundamental idea of the use of air cylinders and the movement of the dipper in a vertical plane from the digging position, over and back of the machine to the dumping position. It has one peculiar feature upon which its promoters place great stress, and that is its ability to do what they call "selective digging."

In case the dipper meets an obstacle that it cannot overcome, it does not stall but automatically raises and slides over it, continuing its full stroke. When all the dirt within reach has been shoveled, the machine is unclamped from the rail, moved forward by hand and clamped again to the rail in the new position. In order to dig across the face of a breast eleven feet wide, the machine is supported on two circular tracks, the center of which is in the rear of the machine, so that the dipper in the dumping position is always directly over the tram car. It will operate within a head-room of seven feet, and the weight is about 4,000 lb. It negotiates with perfect ease any track or curve upon which tram cars can be operated. Comparatively light in weight, simple in mechanism, with no continuously moving parts, it appears to be an extremely promising machine, especially for metal mines. In wet, sticky ore, however, trouble may be expected from the dipper's refusing to discharge. The velocity of the upward and backward movement of the dipper is capable of adjustment and control by means of the cataract cylinder. The machine is clearly beyond the experimental stage, and on a manufacturing basis, built to jigs and templets to secure exact duplication of parts. Just what its limitations are remains to be seen, for in its present form it has been upon the market only a comparatively short time, but is giving very satisfactory results in at least half a dozen metal mines.

In the December, 1918, number of *Coal Industry* there appeared an interesting and complete article entitled "Underground Coal-Loading Machinery," by E. N. Zern, in which is described the Hamilton Loader, built as long ago as 1905. It might be likened to a bucket elevator turned flatwise; and is spoken of as a "flat flight" machine. Fig 21 conveys a pretty clear idea of how an endless chain carrying scraper arms or "flights" deliver the coal upon a conveyor that in turn discharges it upon a car. The article referred to goes on to say: "The Hamilton machine in its original and improved forms was experimented with for two or three years in various coal fields. It did load coal at the rate of a ton a minute. It picked up the coal and left the floor practically clean. It would load extra large lumps, was easily handled, and fairly



FIGS. 14 AND 15. HOAR LOADER IN TWO POSITIONS



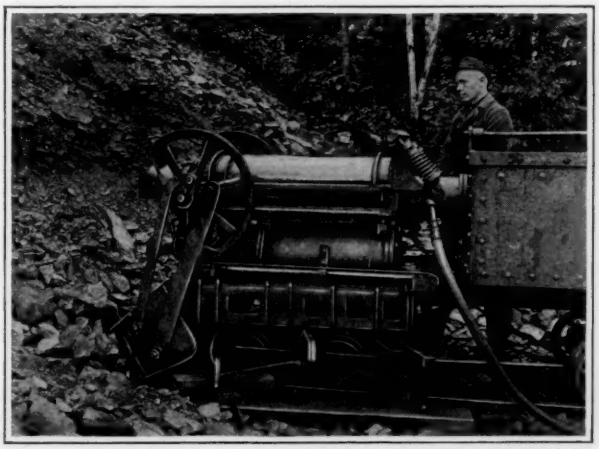
FIGS. 16, 17 AND 18. SUCCESSIVE POSITIONS OF THE MIDDLEMISS LOADER

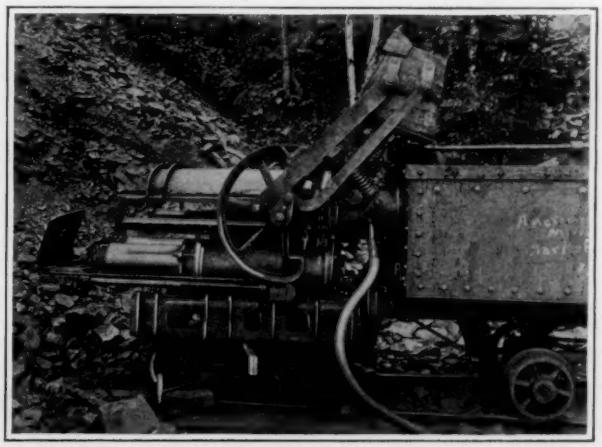
free from breakdowns. To all appearances a machine had been produced which apparently had every requirement and was capable of loading at the rate of 2,000 pounds per minute, or the equivalent of the work of ten men. But in spite of its good features it did not prove to be a success, largely owing to the fact that existing conditions in coal mines rendered it impossible to keep the machine in continuous operation. In some localities it was not permissible to shoot the coal down to the floor, as it would break too much. This necessitated the employment of extra men to pull down the coal, and they were unable to do this in such a manner as to keep the machine busy. This, together with the delays universally encountered in coal mines, left but little time for the actual loading of the coal. Further unavoidable features of the machine were its size and weight and failure to adapt itself to pillar work." The above quotation should be read carefully by too hopeful inventors, for it well illustrates the disappointments they must meet.

For the handling of dirt on the surface the road scraper or "slusher" is a very old arrangement. So, also, underground various modifications of the scraper idea have been used for many years. For a simple scraper system underground in metal mines the first requisite is a small, powerful, portable, reversible, reasonably cheap hoist that can be set up anywhere on a post or drill column and operated by anybody under any conditions. The Ingersoll-Rand Co. make the "Little Tugger" hoist which seems to fill this specification. The use of it in connection with an ordinary road scraper or "slusher" is gaining in favor in the ore mines of Minnesota and Michigan. Its use would seem to warrant the laying out of metal mines with special reference to this method of handling the ore. In Fig. 24 two "Little Tuggers" are mounted on one column, so that the scraper can be hauled back by a tail rope. So far as I know, in the iron mines of the Lake Superior district no tail rope is used, the scraper being hauled back by hand. It is a question whether the use of the tail rope is a real advantage if the haul is less than fifty feet. What appeals strongly in the scheme is its extreme simplicity. In case a straight pull from the breast to the raise in which the ore is dumped or to the car to be loaded cannot be secured, a snatch block can be used to make the turn, but the snatch block is a source of grief and trouble, and should be avoided if possible. Consequently, the mine should be laid out in advance, so that the location of slices and raises is such that the haul shall not be greater than fifty feet—twenty-five is preferable—and the pull on the rope shall be straight. In chunky ore it may be difficult to hold the handles of the scraper, especially when its nose gets under a piece embedded so tight that it cannot be moved.

In one mine where the ore was very wet the scraper was made of slats or bars, and really acted more like a rake than a scraper. It is, of course, a simple matter to make the scraper of a size and construction best adapted for the character of the material. Getting the scraper to dig into a pile and get a full load appears to be the most difficult part of the job. As a rule the two men, one on the hoist and the other on the scraper, change off. Obviously, this scheme is workable in places where it is impracticable to place a loading machine. On the sub-levels it can dispense with track laying entirely if the raises are placed properly with reference to the slices. The results attained at certain mines warrant the belief that this rejuvenation of an old idea has come to stay.

Following certain suggestions of F. E. Keese, general superintendent of the Oliver Iron Mining Co., at Ishpeming, Mich., there was tried underground an arrangement for handling a scraper which appeared to have in it possibilities, but which has not yet been worked out to a satisfactory conclusion. No photographs are available, but Fig. 23 will suffice to explain the idea. By either legs or drill columns a light channel iron is supported near the top of the drift. It carries a sheave on its front end, a "Little Tugger" on its rear end, and a trolley between. Winding up the rope by the hoist serves to drag the scraper into and up the pile of dirt, and when filled it is run backward to a point over the tram car and dumped.





FIGS. 19 AND 20. ARMSTRONG SHOVEL, DIGGING AND LOADING

It is drawn back by hand to the digging position. It was found that in case the nose of the scraper got under an immovable chunk, the man on the handles was likely to go over the top and head into the breast. In dirt that would break without chunks, and, that at the same time, was not sticky, it is probable that the arrangement could be worked to good advantage.

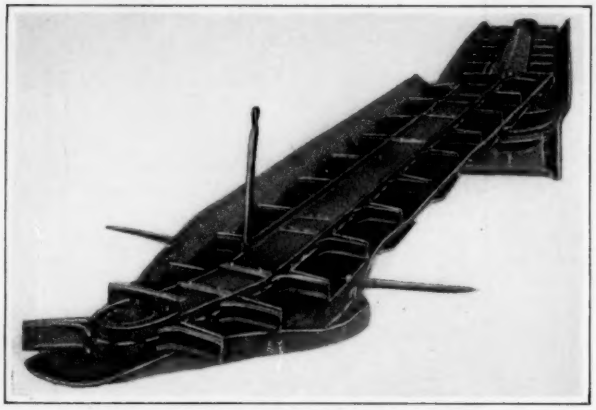


FIG. 21. IMPROVED HAMILTON LOADER

What is probably the most complete and elaborate development of the scraper idea is that known as the Evans System, the invention of Cadwalader Evans, of Pittsburgh, Pa. The Goodman Manufacturing Co. handles the invention and makes the installations. The only real novelties the system seems to possess are the thoroughness with which the details have been worked out and the peculiar "V"-shaped bottomless scraper.

Fig. 22 shows the system diagramatically in elevation. It is customary to install the layout so that it may load out a block of four rooms. A double drum hoist operates a main rope and tail rope, and by means of properly located sheaves the scraper travels the length of the room, making its own path or roadway and discharges its load into the tram car in the entry. Fig 25 gives a comprehensive idea of the scraper and of how it transports the coal. In both anthracite and bituminous coal fields it appears to be gaining in favor. A fairly full description of the arrangement will be found in the *Coal Age* for December, 1918, where the advantages of the system are given as follows:

1. It requires no track in the working place after the first crosscut is made.
2. It uses no complicated mechanism.
3. Delays are few and repairs light.
4. It simplifies the problem of replacing loaded cars with empties.
5. It can be worked in seams of any height, although more attractive to low-seam operations than high.
6. It is not affected by seams of moderate inclination.
7. In case of falls of roof, little or no injury can result, as the hoist is away from the room.
8. It is flexible and can be adapted to the drawing of pillars.

Its disadvantages would seem to be:

1. The capacity of the system is low.
2. The abrasion of the coal in the scoop as it passes over the bottom, along with the churning of the particles, causes degradation of the product.
3. The power consumption in dragging the scoop over the floor is large.

Though undoubtedly the system has been a success in coal mines, it is questionable whether in metal mines it would prove preferable to the very simple scheme described above in theoperation of which a "Little Tugger" hoist, a rope, and a road scraper are all the equipment required.

This article does not pretend to have covered the whole field. No doubt there are many machines that may have been built and tried and proved disappointments and have not come to my attention. There is also a number of machines that are in process of design. No consideration has been given here to a certain type of conveyors specially designed for

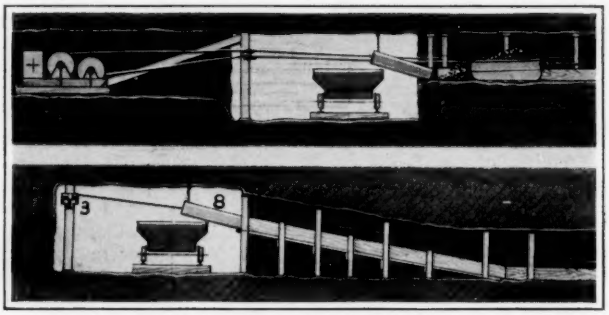


FIG. 22. DIAGRAM SHOWING EVANS SYSTEM IN ELEVATION

use in thin coal seams, which in some cases is made to 300 feet long. In *Coal Industry* for December, 1918, will be found a reference to such machines as well as to certain loaders not discussed here.

From all the foregoing it would appear that development is to be looked for along three general types of machines as

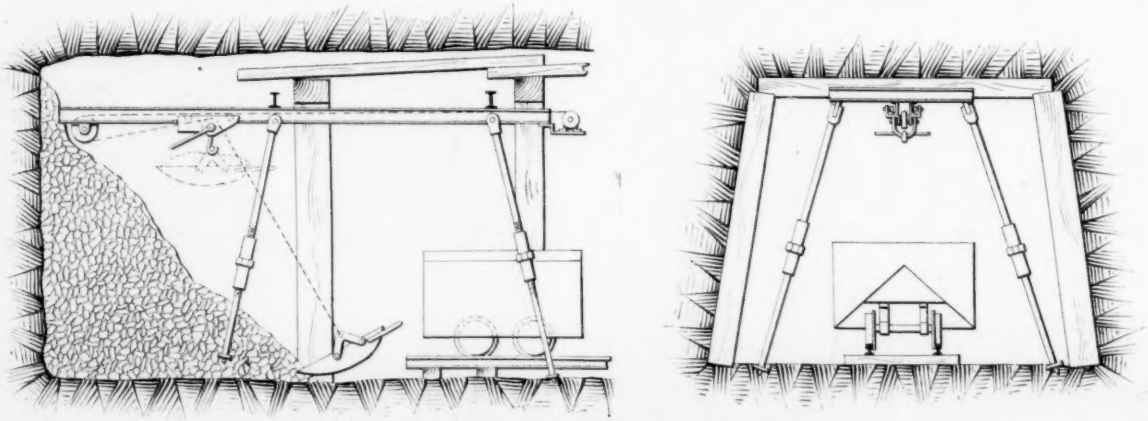


FIG. 23. OLIVER IRON MINING CO.'S SCRAPER

follows: Straight air-operated shovels that throw over in a vertical plane. The Armstrong is an example of an operative machine of this type. Small revolving power shovels, operated by air engines or electric motors. The Hoar and Thew are typical. Machines with a digging element in front, delivering upon a conveyor that discharges into a car. These are represented by the Myers-Whaley, the Halby, and the McDermott.

FIG. 24. SLUSHING UNDERGROUND USING TAIL ROPE, JOPLIN DISTRICT

It is still a question whether or not the machine should be self-propelled. That would seem to depend upon the weight of the machine and whether electric motors are available for moving the machine from place to place. Self-propulsion necessarily involves a complexity of mechanism to be avoided if possible.

Continuously moving parts and continuously moving motors would seem to be conducive to wear and loss of power. A machine of the revolving shovel type operated by direct-acting air cylinders would appear to offer possibilities, but at the same time present many mechanical difficulties. But the field is big enough, the conditions are so variable, and the demand is so insistent that there is little doubt that several types of machine will be developed, giving the mine owner a reasonably wide latitude from which to pick and choose, and reducing the labor of underground loading, with what effect upon the cost sheet remains to be seen.

TEARING STRENGTH OF PAPER.

THAT there is no relation between the actual tearing strength or toughness of paper and the values obtained with the commonly-used paper testers is indicated by the results of recent experiments at the Forest Products Laboratory. The method of test, employing a Schopper tensile strength tester, demonstrated that the toughness of paper can be numerically measured, but that the pop test, breaking length, percentage stretch, and number of folds give very little information about this property.

The following table gives the tearing strength of various papers in grams as determined by the laboratory method and the value obtained in the commonly-used tests:

Kind of Paper	Weight of Ream 24x36	Pop Test	Breaking Length	Stretch	Folds	Tearing Strength
	Lbs.	Lbs. per Sq. Inch	Meters	Per Cent	No.	Grams
News sheet	28	8	2,915	1.0	1	17
Steamed groundwood (brittle)	34	14	4,584	1.5	5	21
Tough kraft (soft feel)	41	44	6,670	3.6	3,020	80
Hard kraft (tinny feel)	52	38	5,320	5.0	556	73
Litho (bleached) sulphate)	44	25	4,860	2.9	248	83
Bond (all rag)	38	37	5,363	5.31	798	88
Ledger (all rag)	87	110	6,335	6.1	2,436	167

OUR OVERBUILT PETROLEUM-REFINERY CAPACITY.

FIGURES recently compiled by the Bureau of Mines, Department of the Interior, show that the petroleum-refinery capacity of the United States is considerably overbuilt. At the present time the refineries have a total rated capacity 50 per cent in excess of the refinable oil supplies, which will be near 80 per cent when the refineries now building are completed.

The oil runs to the refineries of the United States for the year 1919 were 361,520,153 barrels of crude oil, or, 990,466 barrels per day. In December, 1919, the refineries in operation had a daily capacity of 1,356,355 barrels per day, whereas, the daily run of crude oil to the stills was 1,046,052 barrels, indicating that they are running at only 73 per cent of their rated capacity.

It is evident that larger supplies of refinable crude oil are needed by the refineries which are now in active competition in the purchasing of crude oil in the open market. This competition for oil to keep the refineries in full operation has doubtless been one of the influences in the recent advances of crude oil in the United States. Crude oil in the Mid-

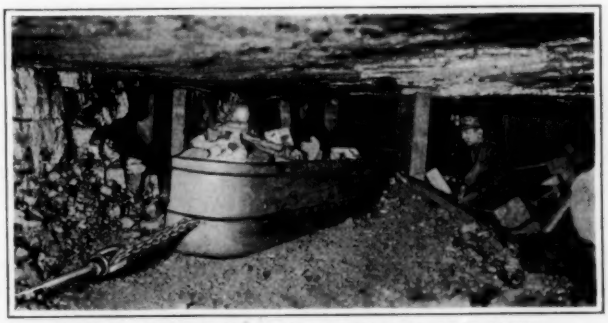


FIG. 25. EVANS SCRAPER IN USE IN A COAL MINE

Continent field, which produces some two-thirds of the refinable oil in the country, has advanced from $2.25 per barrel to $3.50 per barrel in the last few months.

A complete list of the refineries, their locations, and the daily capacities, has recently been compiled by H. F. Mason, Petroleum Economist of the Bureau, Washington, D. C.

Science and National Progress

Edited by a Committee of the National Research Council

Dr. Vernon Kellogg, Chairman, Dr. R. M. Yerkes, H. E. Howe

BUBBLES, DROPS AND GRAINS.

By Wilder D. Bancroft,

Professor of Physical Chemistry, Cornell University, and Chairman, Division of Chemistry and Chemical Technology, National Research Council.

The National Research Council is a cooperative organization of the scientific men of America. It is established under the auspices of the National Academy of Sciences and its membership is largely composed of appointed representatives of the major scientific and technical societies of the country. Its purposes are the promotion of scientific research and of the application and dissemination of scientific knowledge for the benefit of the natioanl strength and well-being.

COLLOID chemistry is the chemistry of finely-divided masses; in other words of bubbles, drops, grains, filaments, and films. This is not an exclusive classification, because each bubble has a film around it and each film may be considered as consisting of coalesced drops or grains. On the other hand, this is rather a convenient way of looking at things, and it can be shown that bubbles, drops and grains, because of their peculiar physical properties, may be very important, both technically and in everyday life.

BUBBLES.

If we add a little oil to a large mass of water and then beat air into it, we shall form air bubbles coated with an oil film in the mass of the water. When these bubbles rise to the surface, the oil film is not sufficiently viscous to keep them from breaking and they will consequently disappear. If we have present any solid which will pass into the oil film and make it more viscous, the bubbles will not break as they reach the surface and we shall have a stiff froth, because the bubbles will practically be armor-plated. This can be accomplished, for example, by shaking up an ore consisting of a sulphide mineral and a siliceous gangue. The sulphide mineral is wetted more readily by oil than by water and consequently adheres to the oil film. The siliceous gangue is wetted more readily by water than by oil and consequently stays in the water, settling to the bottom of the tank. Since the mean density of the sulphide mineral, the oil, and the air, forming the bubble, is less than water, the bubbles rise and we get a stiff, permanent froth, which can be scraped off in any desired way, and which contains, theoretically, all of the mineral and none of the gangue. Practically it does not work out as simply as this, some of the mineral always staying in the gangue and some of the gangue being carried up with the bubbles. However, a very satisfactory concentration can be obtained in this way, and the process, which is sometimes known as the Bubbles Patent of the Minerals Separation Company, is used very extensively in this country. Some years ago it was estimated that twenty million tons of ore were concentrated by this process every year. It is probable that the amount is larger today than it was then. In the early days of this process, while it was being developed in Australia, Herbert Hoover was one of the engineers for the company.

If we blow in a great deal of air, the number of particles of the sulphide mineral on each bubble will be less, and the bubble will be correspondingly less stable. Instead of getting an armor-plated froth, we may get very fragile bubbles which will burst as soon as they reach the surface, allowing the sulphide mineral to drop back. In case this happened, there would be no concentration; but it is possible to remove the mineral just before the bubble breaks. This is known as the Callow process, the bottom of the tank being usually covered with muslin cloth, or something of that sort, through which a large amount of air can be blown in the form of fine bubbles. This differs from the strict bubbles process in that a fragile froth is obtained instead of a stable froth. On the other hand, the two have the thing in common that they both use air bubbles coated with oil as a means of floating the sulphide mineral. The amount of oil necessary is very small indeed, only a few pounds per ton of ore. There are, of course, limitations to the use of either of these processes. If the ore is not ground fine enough, the mineral particles will not stick to the oil film and will not be carried up. If the ore is ground too fine, too much of the siliceous gangue will be carried up with the mineral. The ideal method would be to grind the sulphide mineral fine and the siliceous gangue coarse; but no engineer has yet been able to accomplish this desired result.

A case in which the presence of bubbles has been very important is in the foaming of beer, because people would have refused to drink beer which had no "collar." The stability of this froth is due to viscous colloidal materials suspended in the beer, albumoses, as they are called. If these are removed, the beer does not foam, any more than we get a froth on the surface of champagne.

Bread may also be considered as an extreme case of a permanent froth, since we have air bubbles enclosed in the mass of the bread. We know that the good qualities of the wheat loaf are due very largely to the amount of gluten contained in the flour. On the other hand, there are flours which contain a high amount of gluten and which do not make a good loaf. In order to account for his, the bakers speak about strong and weak glutens. On examination, however, it seems as though all the glutens probably have the same chemical composition, in which case the difference between a strong and a weak gluten must be due either to differences in the amounts of electrolyte present, or to difference in structure. This is one of the problems which is to be studied by the recently founded Institute of Baking in Minneapolis, which is assisted by a scientific advisory committee of the National Research Council.

The characteristic property of ivory soap and some others, that they float, is due to the presence of large numbers of small bubbles in the soap. There is a report, for which I do not vouch, that a chemist once acquired great merit from the soap company by which he was employed, because he made it possible for the company to sell a carton of soap powder twice as large as that sold by the competitors at the same price. What had happened was that the soap powder was full of air bubbles, and the same amount of soap occupied double the bulk. There seems to be no reason to suppose that bubbles in soap add very much to the washing power; but they certainly have a very high advertising value.

DROPS.

Metallic sodium is prepared by passing a current through a suitable bath of fused salt, caustic soda, the molten sodium rising to the top of the bath. Metallic aluminum is made in a similar way by passing an electric current through a fused bath consisting of cryolite, alumina, and a few other substances, the molten aluminum sinking to the bottom of the bath. In both cases we find that the work must be done

within narrow temperature limits. The lower limit is, of course, that at which the bath solidifies. If the temperature is raised too much above the melting point of the bath, the bath acquires the property of scattering small drops of the molten metal all through it, and these drops, coming in contact with the other electrode, are there burned, thereby causing a great loss in current efficiency. If the caustic soda bath is heated 40° above the melting point, absolutely no yield of sodium is obtained, no matter how much current is passed through the cell. With aluminum the temperature limits are considerably wider; but it is desirable not to go more than 60° or 70° above the melting point of the bath.

In the preparation of metallic phosphorus and metallic zinc we have a very different problem in regard to drops. These two substances are distilled from the furnace and are condensed from the vapor form outside the furnace. If either of them becomes oxidized, there is formed a surface film around the drops, and we do not get a compact material. In the case of zinc, the product that is obtained, in case things go wrong, is called blue powder, and contains only 85 per cent zinc.

An emulsion consists of drops of liquid suspended in a second liquid. If we use the generic term oil to signify any liquid which is not mixable with water, we may say that we have two types of emulsions, the one being drops of oil suspended in water, and the other being drops of water suspended in oil. Milk is an emulsion of butter fat in water; butter is an emulsion of water in butter fat. Mayonnaise is an emulsion of oil in water, and so is cod liver oil. Lanolin is an emulsion of water in purified wool fat, and may contain as high as 80 per cent of water. One man has recently taken out a patent for making cheaper printing inks by diluting them with lanolin and water. This is merely producing an emulsion of water in the lanolin and oil which acts as a vehicle for the pigment of the printing inks.

It is, of course, important to know under what conditions one gets an emulsion of oil in water or of water in oil. The general belief is that this is determined by the relative amounts of oil and water, one getting an emulsion of oil in water when using relaitvely little oil, and of water in oil when using a large excess of oil. Recent investigations have shown that this is not so, and that the ordinary emulsions consist of oil, water, and a third substance which forms a film around the drops. The nature of this substance determines the type of the emulsion absolutely, and the relative amounts of oil and water have nothing to do with it. Under certain circumstances we can predict without any difficulty which type of emulsion will be formed. If we have a substance which forms what is called a colloidal solution in water and which is absorbed by oil, this substance will form a film around the oil and give us an emulsion of oil in water. If the third substance forms a colloidal solution in oil and is adsorbed by water, it will emulsify the water in the oil. Typical cases are to be found with the sodium and calcium soaps. The sodium soaps form colloidal solutions in water and do not dissolve in oil. Consequently they emulsify oil in water. The gums act in a similar manner. On the other hand, the calcium soaps form colloidal solutions in oils and not in water. Consequently they may be used to emulsify water in oil. Rosin acts in a similar manner, and in the old days ready-mixed paints used to be adulterated very largely with water, even up to 80 per cent in some cases, the water being emulsified in the linseed oil by the rosin which is always present.

A dilute emulsion is distinctly fluid; but a concentrated emulsion may behave exactly like a solid. Pickering, in England, emulsified 99 per cent of kerosene by volume in one volume of water containing soap. This gave him a stiff jelly which could be cut with a knife and the cubes would stand alone. He noticed the curious thing, that when these solid cubes were left standing in dry air, they liquefied. The reason for this was that the water in the soap films evaporated and the emulsion consequently cracked, setting free the kerosene. The mass did not become liquid because it had taken up water, but because it had lost water. The solid alcohol, which is so popular nowadays, is not an emulsion, although it does contain water. It is, more properly speaking, a jelly.

The books on lubrication tell of an experiment which bothers the authors very much. If one starts with a heavy mineral oil containing a considerable percentage of a calcium soap, and adds water to it, it was expected that the mixture would be more fluid than the original oil, because water is much more mobile than the mineral oil. Instead of that happening, however, the whole mass became solid, giving a grease instead of an oil. The reason for this is very clear to anybody who knows about emulsions. Owing to the presence of the calcium soap, the water was emulsified in the oil, and when enough water had been added a semi-solid grease was formed, just as Pickering had found with intermediate concentrations of kerosene in water.

The pharmacists make a great use of emulsions, and the books on pharmacy are filled with elaborate descriptions as to the methods of making them. The usual way is to dissolve the gum which is used as an emulsifying medium in the water, place this in a mortar, and then add the oil a little at a time with continuous stirring. The chemist is trained to use vessels which seem to stand in some proportion to the amount of substance that he is using. On the other hand, the pharmacists lay down the rule that one must use a very large mortar, the more nearly the size of a bath tub the better. They are also very particular about the way that the mixture shall be stirred. If one starts stirring to the right, one must continue stirring to the right, or no emulsion will be formed. Some books go so far as to say that a left-handed man cannot make an emulsion, which seems a bit absurd. Many of the precautions given by the pharmacists seem foolish; but, on the whole, empirical rules, which have stood the test of years, usually prove to have some foundation, although the reasons given for them may be entirely wrong. This is the case with emulsion-making.

When the chemists started to make emulsions, they said that it ought to be much simpler to add all the oil at once and to shake by machine instead of stirring by hand. This did work well for the dilute emulsions, but it was found that no amount of shaking would give a very concentrated emulsion. At first the chemist thought that this was due to inefficient shaking, and he devised a much better shaking machine, which, however, gave practically the same results. It was then found that if one put the mixture in a bottle, shook it by hand for a few times, allowed it to settle, and then shook again, this intermittent shaking gave results which could not be obtained by doing a thousand times as much work with a shaking machine. It was then clear that one reason why the pharmacist had added the oil a little at a time was because this was equivalent to intermittent stirring, for he stopped between times. Since it is necessary to break the oil up into drops or thin films in order to get a good emulsion, the pharmacist had used a mortar which appeared much too large, because he then spread the mixture over the whole surface of the water, thereby giving him a thin film and consequently a rapid emulsification. We now know the reasons for the pharmacist acting as he did, and we can also get the same results with much less effort.

This experience threw some light on the preparation of mayonnaise. As everybody knows, the making of mayonnaise is a thing which the average housewife approaches with fear and trembling. Everything has to be just so or else the mayonnaise will not come out successfully. Since mayonnaise is essentially an emulsion of oil in water with white of egg as the emulsifying agent, it ought to behave like any other emulsion. The experts in the Departments of Home Economics have no difficulties with mayonnaise. They can add the ingredients in any order; they can add them all at once or in separate portions; they can add them hot or cold; and I know one expert who could actually make a mayonnaise

using the yolk of a hard-boiled egg instead of the white of egg. It was not a very pretty mayonnaise, because it was distinctly granular and looked like the end of a needle when seen under the microscope; but there was no question about its being mayonnaise. On the other hand, these same experts are not able to tell their pupils how to make mayonnaise successfully every time. This means that there is something or other which they do unconsciously and which consequently they cannot tell to their pupils. The experiments with the intermittent shaking seem to give a clue to this difficulty. The expert is so sure of the result that she probably works leisurely and without being hurried or flurried. On the other hand, the person who is not an expert and who is uncertain about the outcome, probably goes at the thing so vigorously as to defeat her own object in many cases. This has not been tested as yet; but I have been told by one expert that she had found that if the materials were beaten well together and then allowed to stand for a moment or two, a couple of swishes would make the mayonnaise. Instead of the conclusion of the pharmacists that a left-handed man cannot make an emulsion, it would probably be more correct to say that a nervous woman cannot make mayonnaise.

The behavior of sodium and calcium salts in emulsion-making throws light on some problems in physiology which had bothered people a great deal. Jacques Loeb and his pupils had found that certain marine organisms died when put into fresh water. This was not surprising, and the explanation that was offered was that the water passed into the organisms, causing them to swell and burst, which was of course fatal. This osmotic pressure explanation, as it was called, came to grief because it was found that the organisms died quite as rapidly if they were put in a sodium chloride or a calcium chloride solution having the same osmotic pressure as sea water. This could not be accounted for on the basis of osmotic pressure. On the other hand, the organisms which died in pure sodium chloride solutions or in pure calcium chloride solutions lived when they were placed in a solution having a definite ratio of sodium chloride to calcium chloride. The explanation has been given by Clowes. If we consider protoplasm as consisting of lipoid materials, which we will call oil, and water, we shall have an emulsion of oil in water in presence of sodium salts, and an emulsion of water in oil in presence of calcium salts. When the sodium and calcium salts are present in a definte ratio, there will be a balancing between these two types of emulsions, and it may well be that this critical state is the one which is conducive to life and growth. As a matter of fact, Clowes found that the ratio of sodium and calcium salts necessary to produce a balancing between the two types of emulsions when working with oil, water and soap, was practically the same as that found in sea water. This shows a very close connection between the two sets of phenomena. Osterhout, at Harvard, has shown that the specific electric conductivity of certain tissues is increased by addition of sodium salts and decreased by the addition of calcium salts. If the hypothetical emulsion changed to one of oil in water, the conductivity should increase, and it should decrease if the emulsion changed to one of water in oil. Clowes has succeeded in duplicating Osterhout's results by impregnating filter paper with an emulsion of oil, water and soap, to which he afterwards added sodium and calcium salts.

GRAINS.

If we take spherical shot and place them in a box so that they are packed uniformly, mathematics shows that so long as the shot are uniform, we get the same amount of metal in the box regardless of the side of the shot. If we add shot of two different sizes, the fine shot goes into the voids left by the coarse ones and we get more shot in the box. If we work with very fine powders, we get a different result, because the finest particles do not pass into the voids left by the coarser powders, but coat the coarser powders. A well-known case of this is sugar and blue-berries. C. G. Fink, who was then with the Harrison Works of the General Electric Company, and who is now Director of Research for the Chile Exploration Company, took equal mixtures of metallic tungsten, which forms a black powder conducting electricity, and of thoria, which form a white powder which does not conduct electricity. If the thoria powder was relatively fine and the tungsten powder relatively coarse, the thoria coated the tungsten and Fink obtained a white powder which did not conduct electricity. If the tungsten was relatively fine and the thoria powder relatively coarse, he obtained a black powder which conducted electricity.

If one mixes a coarse white powder with a very fine red powder, the red powder will coat the white grains and the mass will look almost as red as though it were made of the red powder alone. If the red powder is relatively coarse and the white powder relatively fine, the white powder will coat the red and will mask its color practically completely. This has been known empirically to the paint-makers for a long time, though they have not known the reason for their practice. They are in the habit of adding ground barytes, which is a white powder, as a filler for red paints. They say that precipitated barium sulphate cannot be used. Since barytes is a natural, and consequently impure, barium sulphate, this statement seems to the chemist at first quite inexplicable. The explanation is a very simple one. The precipitated barium sulphate is very much finer than the ground barytes and consequently not so much can be added without interfering with the red color of the pigment.

A flat surface may be considered as a piece of a grain of infinite size. If we look at the reagent bottles in a chemical laboratory, we shall find that some of those which contain solid powders are dirty on the inside. In all cases those will prove to be the ones containing the finest powders, which are able to stick to the glass surface. The same principle of a fine powder sticking to a coarse powder or to a surface is involved when we write with pencil on paper or with chalk on a black board, the only difference being that the paper surface and the black board surface are fairly rough, so that they help to rub off pieces of the pencil or of the chalk. If the piece of chalk which breaks off is too coarse, it will not stick to the black board but falls to the ground.

The ceramic industry depends on the behavior of grains. If we take the clay and burn it, the grains sinter together and we get a porous plate, a brick, or earthenware, as the case may be. If we put in some fusible material, we get the various grades of china and of porcelain. In fact, porcelain may be considered essentially as a silica glass made translucent by grains of the aluminum silicate known as sillimanite. If the whole mass fuses so that the grains disappear, we have a glass. The opaque enamels are glasses in which are suspended white grains of tin oxide, zirconia, or other suitable material. In the case of cement, the clinker is ground to a powder and it is the resulting grains which are used for building purposes.

Porous charcoal is a granular material which came into prominence during the war, because of its use in gas-masks to stop toxic gases. The use of other porous materials, such as pulverulent platinum and nickel, is very important both in times of peace and war, on account of their power to accelerate reactions. The manufacturer of sulphuric acid, ammonia, nitric acid, and hardened oils illustrates the importance of such granular materials, and the list could be extended indefinitely.

Smoke consists of solid particles, usually carbonaceous, suspended in the air; but we also include under the general heading of smoke the solid particles from the fumes of smelters. The Cottrell electrical process enables us to remove the solid and liquid particles from these fumes, and this has proved very effective in California, where people insisted on making cement in the midst of orange groves. The dust thus recovered at cement plants bids fair to be an important

source of potash. While the Cottrell process takes the solid and liquid particles out of the smelter fumes, it does not solve the problem completely so far as the farmers are concerned, because it will not remove the gaseous sulphur dioxide which also damages the crops. At the Washoe smelter of the Anaconda Company, the Cottrell process involves the use of 111 miles of chains merely to make one set of electrodes, the other set being composed of huge plates. This means a possible recovery of 35 tons of arsenic per day.

The flames of burning fires, candles, lamps, and gas jets owe their luminescence to the presence of incandescent particles of carbonaceous material. This can be shown by putting a chilled dish down into the flame, in which case one gets a deposit of soot on the cooled surface. When we put different salts into the gas flame of a bunsen burner, we may get different colors, yellow with sodium, blue or green with copper, and red with lithium. Since the temperatures of these films are, or may be, all the same, the difference in the colors cannot be a question of temperature and must therefore be due to a chemical reaction. It seems probable therefore that with a copper salt, for instance, we have a salt breaking up at the high temperatures into metallic copper, and that the color is due to the alternating formation and decomposition of a copper salt. In order to prove this, one must show that metallic copper is really present in the flame. This can be done easily in a way quite similar to that used for showing the presence of soot in the ordinary flame. If we let cold water run through a porcelain tube and then place this porcelain tube in a flame colored green by a copper salt, we shall get a beautiful deposit of metallic copper upon the porcelain. Similar results can be obtained with salts of the other metals. In some cases, as with tungsten salts, no metal can be obtained when using the bunsen burner, because the temperature is not high enough. By putting these salts in the oxyhydrogen flame, it is possible to obtain a deposit of metallic tungsten on the porcelain tube. Of course, this suggests a wonderful possibility in perpetual motion. All one has to do is to burn coal and air to carbon dioxide, heat the carbon dioxide to a temperature at which it will break down to carbon and oxygen, collect the two and burn them over again. This could actually be done, but of course not economically.

In the photographic plate we have grains of silver bromide dispersed in a gelatine film. It is the gelatine adsorbed by the grains of silver bromide which determines the speed of the plate; it is the silver adsorbed by the grains of silver bromide which gives rise to the latent image; and it is the reducing agent or developer adsorbed by the latent image which makes the picture.

Reference has been made to the fact that a film may be considered as made up of coalesced grains or drops. These may also be very important in many cases. Aluminum should be oxidized very readily and should, theoretically, be of no value for everyday use. As a matter of fact, there is formed on the surface a film which protects the aluminum from further chemical action. The same thing occurs with nickel. If iron rust formed a coherent film which protected the metal, rust would not be a serious phenomenon with iron any more than it is with aluminum or nickel.

One of the important things in chemistry is to make use of the waste products. As has been stated, blue powder consists of 85 per cent zinc. By heating this in presence of iron, some of the zinc sublimes over and condenses on the iron, giving a galvanized surface. The process is known as sherardizing, from the man who invented it. It has become so important that the supply of blue powder is not sufficient for the needs, and it is necessary to make a zinc powder from good zinc in order to keep pace with the demand.

When we put oil on a road, the oil forms films around the grains of the road material and binds them together. We do the same thing in making foundry cores, except that there we use an oil-water emulsion instead of oil alone. If the liquid film is of a suitable thickness, the mass becomes plastic. In making fondant, the two important things are to heat the mixture so as to change just enough of the sugar over into a non-crystallizable form, and to stir so rapidly that the sugar which does crystallize comes down in very fine grains, coated with a syrupy film due to the invert sugar. That gives us a plastic mass having the desired properties. When pigments are mixed with linseed oil, we get a plastic mass, in which the linseed oil finally dries to a solid material, which holds the pigment to the material painted and which forms a protecting film over the surface of the material. In the case of glue and other adhesives, we have a liquid film which gradually solidifies and which is used to hold the two surfaces together. In the case of varnishes and lacquers, we have a liquid film applied to a surface and which dries finally to a solid film, which is both protective and decorative.

These illustrations are probably sufficient to show the importance of bubbles, drops and grains, which are the subjects of study of colloid chemistry. It is not too much to say that colloid chemistry is the chemistry of everyday life.

GOVERNMENT MAPS.

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THE bringing together of men from all parts of the country at Plattsburg, and later in the various cantonments and officer training camps, awakened in them a new interest in geography and in the study of maps, which had lain dormant or become atrophied since boyhood days. More than one officer-in-embryo, lost in the woods with a small detachment, found that he could work his way out by the map which he had in his equipment. At first he regarded the curved brown lines as a nuisance detracting from the clearness of the map, but soon he learned to prize them as a picture of the hills and valleys, and a prophet of the roughness of his coming "hike." To many this was the first introduction to the topographic map of the United States. Some few had learned of these maps in automobiling, but practically none of the boys, except a few collegians knew anything of how the maps are made or of the work which the Government is doing to produce and supply accurate topographic maps of its vast domain.

The topographic branch of the U. S. Geological Survey was organized about thirty years ago through the consolidation of previous organizations for surveying the territory west of the 100th meridian—the Rocky Mountains, and the regions westward to the Pacific Coast. The initial aim was the preparation of a geological map of the public lands to assist in the development of the natural resources of this vast and sparsely settled region. But the need of good maps for all the country immediately led to an extension of the service to include the whole nation. The present aim of the geological survey is to cover the United States with a general utility map, supplementing this with special purpose surveys on larger scales when such are necessary. In spite of thirty years of activity only 43 per cent of the area of the United States has yet been covered by standard topographic maps and a fifth of these now need revision. It is estimated that it will require nearly fifty million dollars and fifteen to twenty years to complete the map, though the work can be done in twelve years if Congress makes the necessary appropriations.

Besides the Geological Survey, there are thirteen other Federal map-making organizations with more or less complete technical staffs and separate appropriations, as follows:

1. *The U. S. Coast and Geodetic Survey* prepares coast charts and larger-scale harbor charts which give the depths of the water, and the shorelines and topography as far inland as can be seen from the water. It also supplies the geometrical network and basic vertical control on which the local maps of the Geological Survey are constructed.

2. *The Hydrographic Office of the Navy Department* makes original surveys and publishes maps, but its work is entirely

outside the continental limits of the United States. When it needs shore topography as an aid to navigation, the maps are based on pre-existing work or on original surveys.

3. *The Corps of Engineers, U. S. A.* prepares detailed topographic maps with military information in the vicinity of strategic points where military operations are probable. It also prepares the special maps necessary for practically all Federal improvement projects such as river control, canals, etc. Many of these maps contain confidential military information.

4. *The Mississippi River Commission* prepares maps of special types dealing with the hydrography of the river and the topography along the shores. This Commission publishes its own maps and issues pamphlets giving information as to its benchmarks, changes in the bed of the river, and other features of value to river pilots.

5. *The U. S. Lake Survey* publishes navigation charts of the Great Lakes, the New York State Canals and the Lake of the Woods.

6. *International Boundary Commission.* This Commission is charged with the survey and marking of the International boundary between Canada and the United States from the Arctic Ocean to Cape Muzon and from the Atlantic to the Pacific, excepting through the Great Lakes, the St. Lawrence and connecting waters. According to the treaties the lines must be described in reliable maps, and it has therefore been necessary to make a topographic survey of a strip a mile or so in width all along these lengthy lines. The published maps will conform as far as possible with those made by the Geological Survey.

7. *The Forest Service* uses the standard topographic map when possible, but it makes surveys and maps for its own purpose as occasion requires. These conform in general to the standard topographic map when based on original surveys, but often maps are compiled from such meagre information as may be available. The scale of its maps are just a trifle different from the standard topographic map.

8. *The Bureau of Soils* uses existing maps whenever possible, but to meet the demands of farmers' organizations and Congressional requests in all the states of the Union it is often forced to use any map available, such as Land Office maps or local county atlas sheets. Very frequently it makes traverse maps of its own. The scales of the maps and their accuracy, therefore, vary widely at times from the standard topographic maps. The unit of publication is usually some minor political subdivision, so that the sheets vary in size or scale.

9. *The Reclamation Service* makes a wide variety of maps to cover its needs in the construction of irrigation and drainage works and in the classification of the lands for irrigation purposes. These maps vary from preliminary reconnaissance surveys to refined surveys for reservoir sites, and therefore differ widely in scale and accuracy.

10. *The General Land Office* is primarily interested in subdivisions showing public and civil land boundaries, especially in the Public Lands and Indian Reservations. The character and scales of the maps vary widely. Some are based on actual surveys while others are merely compilations from county or commercial maps.

11. *The Bureau of Indian Affairs* uses whatever suitable maps are available, and where these do not exist makes maps based on its own surveys. These differ widely in scale and character.

12. *The Bureau of Public Roads* is a map-using rather than a map-making agency, but in carrying out the program of the Federal Aid for roads project it will coöperate with other agencies in the preparation of State road maps. Moreover, during the surveys of roads constructed under its supervision much information in the way of traverses and levels will be gathered which will be of great value to engineers interested in public works.

13. *The Topographic Branch of the Postoffice Department.* Although this organization does not maintain surveying parties, it sends numerous inspectors over the country and compiles and publishes Post Route maps, Rural Delivery County maps, and maps of local centers.

Such a multiplicity of government agencies doing much the same sort of work in surveying and publishing maps leads inevitably to excessive costs and confusion both to the Federal and non-Federal users of maps. Every industry, art or science, governmental or otherwise, which requires a knowledge of the lay of the land is dependent on suitable maps, and detailed work requires specific information regarding facts determined during the making of such maps. An immense wealth of such information has been collected by the several map-making agencies, but experiences during the war have emphasized the fact that few officials and fewer civilians know where to turn to get the specific information desired at the moment. To overcome the lost efficiency, due to overlapping among the Federal agencies, and to reduce the confusion as to where information already secured might be obtained, the President, by Executive Order of August 27, 1919, convened an Interdepartmental Conference of all the Federal Map-making Organizations. This conference, after several sessions, filed a report including the following recommendations:

1. That a permanent Board of Surveys and Maps, composed of one member from each of the Government organizations represented in the conference, be appointed to act as an advisory body on all questions relating to surveys and maps.

2. That a central information office be established in one of the Government map-making agencies, preferably in the U. S. Geological Survey, for the purpose of collecting, classifying and furnishing information concerning all maps and survey data available in the several Government organizations and from other sources.

It was further proposed that the new Board should confer with those interested in the making and using of maps and thereby establish closer coöperation between the work of these outside agencies and that of the Government. In order to make such coöperation effective, representatives of the Engineering Council, American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Mechanical Engineers, American Institute of Electrical Engineers, American Association of State Geologists, American Association of State Highway Officials, The National Research Council, the Association of American Geographers, The American Geographical Society, and the Geological Society of America met at the rooms of the National Research Council and organized under the chairmanship of Professor Edward B. Mathews, Chairman of the Division of Geology and Geography of the National Research Council.

After several subsequent conferences and correspondence with map publishers, educational institutions and map-users, this committee has prepared a report with recommendations which will be presented to the permanent Board of Surveys and Maps which was established by Executive Order on December 30, 1919, "to coördinate the activities of the various map-making agencies of the Executive Departments of the Government, to standardize results, and to avoid unnecessary duplication of work."

In pursuance of this Executive Order the Board has met, organized, and established its methods of procedure. It purposes to establish at an early date a map information office in the Interior Department Building, Washington, D. C., which will collect and catalogue, as rapidly as possible, information concerning maps, surveys and survey data, not only of the Federal Government, but of other Governmental and private agencies. The members of the new Board desire that this information office shall be of service not only to the Federal Departments and Bureaus, but to the general public. The Board would welcome suggestions concerning the means whereby this office can be of most public value and hopes that the fullest use will be made of its facilities. Such suggestions may be sent direct or transmitted through the committee representing outside agencies mentioned above.

Research Work of the United States Bureau of Standards

Notes Specially Prepared for the SCIENTIFIC AMERICAN MONTHLY

RADIO RESEARCH AND CO-OPERATION WITH UNIVERSITIES.

THE radio laboratory of the Bureau of Standards is coöperating with various university laboratories in research work. The service which the Bureau of Standards laboratory can render to the universities includes the furnishing of research suggestions, technical data and publications, advice on particular technical problems, and in the standardization of instruments and apparatus for the university laboratories. A number of the universities have been supplied with information and suggestions of assistance in the prosecution of scientific research work upon such subjects as radiotelephony, methods of radio measurement study of electron tubes, and the development of circuits for particular purposes in the production and detection of radio currents. Information on radio laboratory equipment has likewise been supplied. Another way in which coöperation is furthered is by assistance in the publication of technical results by reading and criticizing papers and books prepared by research workers.

Radio instruction in a number of the universities has been facilitated by the use of two of the publications prepared by the Bureau's laboratory, "The Principles Underlying Radio Communication" and "Radio Instruments and Measurements." The first is an elementary non-mathematical introduction to electricity and radio, and the second is a fairly advanced text on radio measurements and theory.

One of the investigations now in progress at the Bureau's laboratory is adapted to direct coöperation in the experimental work between the Bureau and the universities. This is the study of radio waves and their behavior. Measurements of radio wave intensity and direction carried on over a long period of time will make it possible to learn much about the way in which waves function and will make possible rapid advaices in the control and utilization of the waves in radio communication for commercial purposes. It is found that the waves exhibit great variations with time, weather conditions, and type of ground travelled over. From this work it will be possible to calculate the strength of the signal which will be obtained at a distant station when the current used at the sending station and the distance and other factors are known. With this end in view, signals are being sent out from the Bureau's laboratory and careful measurements made upon these signals at a distant univesity laboratory. University workers who desire to coöperate in this research will be assisted by the Bureau, and arrangements will be made to standardize the aparatus which they use for measurement.

The following radio laboratory reports in connection with radio research are available:

Suggestions for Radio Research;
Fees for testing Radio Apparatus;
List of Manufacturers of Radio Apparatus;
List of Manufacturers of Electron Tubes.

A list of desirable research problems on radio waves is given in Bureau of Standards Scientific Paper No. 354, "Principles of Radio Transmission and Reception with Antenna and Coil Aerials." A suggested list of laboratory experiments for radio training sources is given on pages 342-349 of the publication mentioned above, "The Principles Underlying Radio Communication."

RADIO SUBJECT CLASSIFICATION.

One of the important duties of modern scientific research organizations is that of keeping in touch with the literature of the subjects studied. In its work as a clearing-house of information in radio science and engineering, the Bureau of Standards radio laboratory has felt the need for a systematic scheme of classification of subjects. Such a classification is needed for references to radio publications, books, drawings, reports, miscellaneous data, and information. A tentative scheme of classification has been prepared, grouping subjects of radio interest under the following principal headings: Radio Wave Phenomena; Antennas; Electron Tubes; Radio Measurements; Properties of Materials; Radio Theory; Radio Research; Radio Instruction; Miscellaneous Radio Apparatus and Methods; Radiocommunication and Applications; Radio Miscellaneous; Electrical Subjects Related to Radio, and Miscellaneous.

It is desired to make this list as complete, comprehensive, and usable as possible, and with this end in view, the Bureau of Standards will be glad to send a copy of the complete classification to any persons interested, with the object of securing suggestions as to its possible improvement.

PHYSICAL CONSTANTS OF INTEREST TO THE REFRIGERATING INDUSTRIES.

Of the numerous investigations on physical constants of materials which are being conducted at the Bureau of Standards, a number that are of particular interest to the refrigerating industries have recently been completed and prepared for publication. The physical properties of ammonia are of greater interest to the refrigerating industries than those of any other material since ammonia is the medium used in by far the largest number of plants.

Two recent papers deal with the vapor pressure of saturated ammonia and with the densities of the liquid and of the saturated vapor. In connection with the determination of the vapor pressures, use was made of a pressure gage of unique construction, which proves to be very accurate. A paper dealing with the specific heats of sodium chloride solutions which are used in making of artificial ice has also been completed.

These papers will be published in the course of the next few months in the *Journal of the American Society of Refrigerating Engineers*, which has its headquarters at 154 Nassau Street, New York City. A more detailed account will be published later by the Bureau.

NEW CHEMICAL PUBLICATIONS.

Several publications have recently been issued by the Chemistry Division of the Bureau, and some articles by members of the Bureau's staff have appeared in scientific journals which are of interest to all those engaged in chemical work.

A list of these, with short abstracts, giving the salient facts contained in each pamphlet, is as follows:

(1) A New Hexabromide Test for Linseed Oil, by L. L. Steele and F. M. Washburn. Published in the *Journal of Industrial and Engineering Chemistry*, January, 1920.

"Various published methods for the determination of the hexabromide yield of linseed oils have been investigated, especially the Eibner method. An explanation is given of the observed fact that this method does not yield concordant results. Experimental work leading to the development of a new hexabromide method is given, the main features of which are the addition of bromine to the fatty acids of linseed oil in a solvent in which the resulting hexabromide is soluble, the addition of a reagent to remove excess bromine, the removal of the solvent by evaporation, and the isolation of the hexabromide free from contaminating bromides by thorough washing with absolute ether saturated with hexabromide. A table of

results obtained so far indicate that the hexabromide yield of pure raw linseed oil is a more constant value than the iodine number. Results are also given on mixtures of linseed and other oils, such as soya bean oil, which indicate that it may be possible to estimate quantitatively adulteration of linseed oil with other oils which give a low hexabromide yield."

(2) Specification for Basic Carbonate White Lead, Bureau of Standards Circular No. 84.

(3) Constant Temperature Still Head for Light Oil Fractionation, by F. M. Washburn. Published as Technologic Paper No. 140, and in the *Journal of Industrial and Engineering Chemistry*, January, 1920.

"The paper gives a brief review of the three types of methods generally in use for the fractionation of light oil and describes an apparatus which is an improvement on the dephlegmator of the Wilson and Roberts still. The use of a constant-temperature still head, consisting of a spiral of iron pipe immersed in an oil-bath, electrically heated, and regulated by means of a thermostat, makes it possible to condense out practically all of the constituents having a higher boiling point than the fraction desired. The vapors pass first through a Hempel column and then through the still head. The construction, manipulation, and accuracy of the apparatus are given in detail, together with its value and applicability to the benzol industry."

(4) Detection and Determination of Glue in Rubber Goods, by S. W. Epstein and W. E. Lange. Published in *Rubber Age* and to appear as a technologic paper.

"The authors investigated the various procedures which suggested themselves for the detection and determination of glue in vulcanized rubber. It was found that the only quantitative procedure to determine the glue content was the Kjeldahl nitrogen determination. This was found to be satisfactory with certain variations which are given in the paper.

"The authors discovered that cresol dissolved glue even more readily than water, and that the resulting solution precipitated 70 per cent of its glue content on the addtion of petroleum ether. Since rubber remains in cresol solution when petroleum ether is added, there is here a means of separating glue from rubber. These behaviors are made use of by the authors in their qualitative method. Details by which this separation is carried out are presented by the authors in their recommended procedure for the detection of glue in rubber. Results are given showing that as little as 0.9 per cent of glue can be detected. From the results of many experimehts, the author's point out that the procedure is reliable in every case, and that no substances will interfere with the test."

In conclusion the authors make the following statements:

"1. A method is presented which will detect as little as 0.9 per cent of glue in a rubber "mixing." It has been found by experiment, that no substance other than glue will answer to this test when carried out as directed. The procedure is reliable and convenient.

"2. When glue is present in a rubber sample its quantity is arrived at by determining the nitrogen content by means of the Kjeldahl procedure and calculating this to glue. We have been able to find no other satisfactoy quantative method which would give the correct percentage of glue."

EFFECT OF STRIAE IN OPTICAL INSTRUMENTS ON RESOLUTION.

As a result of some of the work performed by the Bureau of Standards on optical instruments, it was found that a certain amount of striae might be permitted in the lens systems of such instruments without having any bad effect on the operation of the complete apparatus. Work is now nearing completion on the design of a proper resolution chart which is preliminary to the investigation of the effect of striae in an optical system on its resolution. A report on this preliminary work is being prepared which presents curves showing the relation between the resolution of a telescope and the intensity of the illumination of the test chart. Other curves plot the relation of the resolution to the degree of contrast between the background of the chart and the lines ruled thereon. These curves were obtained by using different types of charts, such as one ruled with a 1 mm. line having sharp edges, another with two or more narrower lines, etc. The results so far obtained indicate that considerable assistance may soon be extended to the manufacturer with whom rests the decision as to how much striae he may permit in the prisms and lenses of his optical systems.

CAMERA FOR MEASURING THE INTERIOR OF RIFLE BARRELS.

In connection with the determination of the amount of erosion within gun barrels after certain amounts of firing, the Bureau has been called upon to construct a camera which will make a panoramic view of the inside of the barrel. Work on this camera is progressing rapidly. The lenses have been designed and the work on other parts is nearly completed. If the camera proves to be a success, it will be possible to study the interior condition of a small gun barrel at any period of its life without the necessity of sawing through the barrel lengthwise, which was the only means known before this camera was suggested. The investigation of the interior of the gun can then be carried on without destroying the barrel.

A MINING GLOSSARY.

THE mining industry has long felt the need for a comprehensive, thorough and complete glossary of the terms used in its various branches. This requirement has been met recently by Albert H. Fay, Mining Engineer, U. S. Bureau of Mines, author of Bulletin 95, "A Glossary of the Mining and Mineral Industry," which contains about 20,000 terms and nearly 30,000 definitions covering all phases of coal and metal mining, quarrying, metallurgical plants, coke-ovens, oil and gas wells, geology and mineralogy.

The words are arranged alphabetically in true dictionary style, there being no industrial grouping. Only one glance is necessary, therefore, to find any desired term. The type and style of composition are such as to render it easy to find the word, and read the definition.

A cursory glance through the 754 pages reveals years of research, and painstaking study in preparing, assembling and coördinating the definitions from many and varied sources, and inserting proper cross references. The scope of the work includes all English-speaking countries, as well as much that is Latin-American. Usually the name of the State, province, or country is given showing where the more provincial terms originated or where they are extensively used.

In most cases the name of the author quoted is given in parenthesis at the end of the definition, thus making it possible to trace the term back to the publication in which it previously was defined. The use of the author's name has possibly resulted in some variation of syntax, as in general, too much alteration would not be permissible, and still quote the definition. About 150 authors are quoted as indicated by the list of publications cited, 100 of which publications contained glossaries relating to some phase of the mining industry.

The glossary contains many words that are more or less obsolete and this feature may be considered an advantage rather than a detriment, as the older literature contains many terms that are not now current. The scientist engaged in research work is always glad to know where the older terms are properly defined.

Some of the terms that have figured in mining litigation, as for example, "abandonment and forfeiture," "apex," "fissure," "lode," "vein," and scores of others, have been given special attention, a number of similar but slightly different interpretations being given and many court cases cited wherein the decisions were rendered. These court citations in addition to definitions from other sources add much to the value of the publication from a legal standpoint.

Progress in the Field of Applied Chemistry

Notes Culled from Current Technical Literature

PHOTOGRAPHIC RESEARCH.

THE British Photgraphic Research Association has published some of the results of its work; one contribution being upon "The Fundamental Law for the True Photographic Rendering of Contrast," and another deals with "Contrast and Exposure in X-ray Photographs Through Metals." In this last article, the point is made that in photographing through a centimeter or more of metal the photographic effect is almost entirely due to the hardest rays, and the contrast obtained depends only on the quality of these rays and not on the absolute thickness of the metal. Also the softer these hardest rays are, the greater is the contrast. This may at first sight appear to be opposed to experience, but the explanation is as follows:

Suppose we photographed a piece of iron 1 cm. thick containing a bubble of half a millimeter diameter, we can easily obtain a good contrast on the photograph. Now if you want to photograph a bubble of the same diameter in a piece of iron 6 centimeters thick, we can do so and obtain the same amount of contrast if we use the same voltage on the X-ray tube but increase the exposure many thousand times. In practicing with a piece of iron 6 centimeters thick we use a harder radiation to get a reasonably short exposure, and consequently the contrast obtained is very much less.

These observations have a bearing upon work now in progress here on the use of X-rays as a means for detecting defects in metals, leading to a process which can be employed in inspection without destruction of the sample.

The Association has also published a short discussion on "The Properties of an Emulsion to give the best result in a process plate." As much as possible of the silver bromide should be in grains of the same size, and the presence of a small number of grains larger than the majority would have a worse effect than the presence of the same number of smaller grains, because the larger grains give rise to more silver on development. The absolute size of the grain does not seem to matter very much as long as they are all of the same size.

BIBLIOGRAPHIES.

BOTH the starting point and the goal of research is information, and before any problem can be properly undertaken the research worker must determine from the literature that which has been done in similar fields or those closely related to it. Bibliographies, therefore, become a most important source of information. They are something which are time consuming for preparation, always represent a large amount of effort, and are expensive to duplicate. The use for any particular bibliography, however, is ordinarily limited to the few people working in that special corner, and consequently the publication of exhaustive bibliographies is seldom undertaken on a commercial basis. They are expensive to publish and very rarely have a circulation which justifies a publisher in undertaking their reproduction.

An interesting example of this is a certain work in zoölogy and other special fields in biology which has been published in Europe for some years. It is of immense assistance to research workers, and yet it operates with an annual deficit.

Some of our libraries issue carefully prepared bibliographies and notable among these are the libraries of the engineering societies and the Carnegie Library at Pittsburgh. The obvious importance of bibliographies and the infrequency with which they are published leads us to comment upon three which have recently appeared. Two of these "Chemical Warfare" and "Industrial Research" first appeared in *Special Libraries*, while the third, "The Production of Alcohol from Sulphite Waste Liquors," appeared in *Paper*. These have since been reprinted by Arthur D. Little, Inc., whose information department was responsible for the compilation. The ones upon Industrial Research and Chemical Warfare may be recommended to those interested in supplementary reading. A considerable variety of subjects is covered under the head of Industrial Research.

SCIENCE IN THE LEATHER INDUSTRY.

IN the February number of the *Journal of the American Leather Chemists' Association* there occurs the following abstract from an article in *Le Cuir* entitled "Science Applied to the Leather Industry":

"During the war the overwhelming demand for leather forced the question of quality to be subordinated to that of increased production. Such a policy continued in peace times would spell disaster to the industry. A new struggle for commercial supremacy has begun that will require the production of leather of high quality at a low price. Regret is expressed that the commissariat did not know enough to profit by its unique opportunity to prepare for the after-war period, although this is to be expected where chemists and specialists are not represented. But it is the future, not the past, that matters now and the secret of solving present problems lies in the application of science to the industry.

"Methods of preserving hides should be investigated by means of our knowledge of antiseptics, bacteriology and the principles of putrefaction. Both physics and chemistry can be brought into play in determining the best methods of soaking to prevent loss of hide substance, and to deal most effectively with very hard and dry hides. Microbiology and chemical studies should be made of the liming process and of the actions of sodium and arsenic sulphides, both alone and mixed with lime. Much credit is due to Wood for his noteworthy bacteriological studies of bating, and to Proctor and Meunier for their works on the theory of tanning. A vast field for scientific investigation is offered in the matter of tanning materials which are now derived from all three kingdoms of nature.

"Although the above survey is brief, it indicates how much the development of the industry is dependent upon the application of science and the author hopes it may inspire tanners to wish to know more about such matters."

TEXTILE LEGISLATION.

CONSIDERABLE editorial comment has been brought forth by the Barclay Bill (H. R. 2855), which has recently been brought before Congress. Briefly stated, the bill provides that no article of commerce may be marked in any way so as to give fraudulent, misleading, or inaccurate information as to weight, measure, numerical count, materials from which it is made, place where it is made, mode of manufacture, whose manufacture the product is, or information that its quality is superior to that which it really is, or information which is false, misleading, or deceptive in any other particular.

The bill intends to enable wholesaler and retailer to depend upon the guarantees of the producer, upon whom the responsibility for conforming to the law may be placed.

On numerous occasions effort has been made to give the ultimate consumer the same assurance that he is receiving that which he thinks he is buying in other articles beside foods, and certainly there is nothing to be said against the idea that the consumer should be properly protected against fraud of

any kind. However desirable such legislation may be, the difficulties to be overcome in enforcing the law are sure to be great and to involve rather extensive machinery. Due to the ideas which have been implanted in the minds of most of us with respect to the superiority of one type of material, say wool for example, it would be also possible for some particular section to profit largely. The writer believes in making it possible for the purchaser to know what he is buying, but he also believes in having the purchaser realize that nearly all fibers have their important place in our economic structure and that a piece of material may be better because of the admixture of the cotton with the wool. This does not relieve the manufacturer, wholesaler, or retailer from the obligation to sell such fabric for exactly what it is.

In some of our cities there are ordinances designed to deal with unfair competition and misrepresentation in advertising. In one of these cities the law has been enforced on occasion and the chemical laboratory has been successful in establishing the facts relative to the misrepresentation of merchandise, in this instance, silk. In Germany there have been a number of laws on this subject, the last of which is quite broad. The German bill goes so far as to give in detail advertising practices which are forbidden. Thus bankruptcy sales are very carefully covered and the merchandiser may not describe his sale as "On account of alterations," "direct from factory," "selling at factory price," "damaged by water," or "fire sale," unless the description fits the facts. Imagine some of our merchants being forbidden to use "hand-made," "selling at factory prices," "direct from manufacturer to consumer," and similar catch phrases unless such were the facts!

Great Britain also has an Act which covers much the same ground as does the Barclay Bill. The better class of merchants would no doubt welcome such legslation if it can be enforced in a way not to put a premium upon dishonesty. Some of our merchants have already established their own chemical laboratories, used as a protection both for themselves and for their customers, and the day is pretty sure to come when they will reap the benefit of their foresight.

PROTECTION AGAINST CARBON MONOXIDE.

CARBON monoxide is the poisonous constituent of illuminating gas and is responsible for the deaths of persons who prefer to commit suicide by the gas route. This same gas also causes trouble when burners upon gas stoves are not properly adjusted, or where the distance between the burner and the vessel to be heated is not such as to allow proper combustion. Carbon monoxide is also to be found in the exhaust vapors or fumes from internal combustion engines and is accountable for the death of several people who endeavored to work in a closed place with a running motor. Another source of danger from carbon monoxide is to be found in burning buildings which a fireman must enter. In coal mines and elsewhere, where explosives are used in confined places, carbon monoxide is a serious menace, and even in the metal industries fatalaties have occurred where illuminating gas is used for brazing, etc.

In addition to these various sources of danger in peace occupations there are so many military considerations that special work has been done to provide defense against it. At one time the statement was made that the nation which first learned how to use carbon monoxide in warfare would be sure to win, and while the gas could not be made available for warfare it does occur in considerable quantity where there is much gun-fire. Machine gun-fire, particularly in closed places, liberates large quantities. It is stated that in one of the naval engagements, defective high explosive shells evolved large quantities of carbon monoxide after penetrating into enclosed portions of ships causing the death of many men.

A new compound, which is called ohpcalite, was developed to remove carbon monoxide from the air. As first made it consisted of a mixture of 50 per cent manganese dioxide, 30 per cent copper oxide, 15 per cent cobalt dioxide and 5 per cent of silver oxide. Some modifications have since been made. The mixture gradually decreases in efficiency due to the absorption of moisture. This can be checked by weighing the container from time to time.

FIXED NITROGEN.

PROFESSOR ALFRED H. WHITE of the University of Michigan is the author of an article on "The demand and supply of fixed inorganic nitrogen of the United States," appearing in *Chemical and Metallurgical Engineering* for February 25th. An analysis of statistics is given and it is shown that in 1913, out of 626,000 long tons of Chilean nitrate imported 37.2 per cent was used for explosives, 45.5 per cent found its way into fertilizers, and 50.3 per cent served as raw material for the manufacture of chemicals. In addition 65,775 short tons of ammonium sulphate were imported, 15,000 tons of cyanamide were produced, and the domestic production of ammonia from coke ovens and gas works, calculated as ammonium sulphate, was equivalent to 195,000 short tons.

By going back to 1900, and plotting the curves for demand, sources and supplies it will be seen that an ever increasing amount of fixed nitrogen must be provided for agricultural and our chemical industries, including explosives. The question then becomes whether we can afford to allow the Government-owned plants for the fixation of atmospheric nitrogen to remain idle.

Professor White estimates that, based upon the capacity of the Government plants and the calculated demand, we must import 60.4 per cent of our inorganic nitrogen if the Government plants remain idle in 1920; but only 42.1 per cent if they are operated. This becomes 66 per cent and 50.5 per cent, respectively, for 1925, and 71.6 per cent and 60.7 per cent in 1930.

The two principal methods for the fixation of atmospheric nitrogen are by the synthetic, or Haber process, and cyanamide. Neither of these processes has so far proven a commercial success, and yet they represent the best that has been done. The Government plants exemplify these two principal processes. It is believed that the cyanamide plant in particular can be operated to produce fertilizer at a cost which will pay running expenses. In any event the United States cannot afford to be behind the procession in the study of nitrogen fixation. It is urged that steps be taken to bring the Government plants into production in order to diminish our dependence on imported material. The rapid increase in the installation of by-product coke ovens is an important factor, but even if all the coke produced in the country was made in by-product ovens the ammonium sulphate recovered would fall far short of meeting the demand for fixed nitrogen. Our war experience with nitrogen should teach a sufficient lesson to encourage further work on this subject.

HAIR DYE.

E. C. GRAY is the author of a discussion on "The Dyeing of Human Hair," appearing in the *Color Trade Journal* of February. It seems that in the Western Hemisphere powdering the hair was the established custom for many years, originating in Rome, where gold dust was reported to have been used at one time. As late as 1806 the fashionable young men in London made a practice of powdering their hair blue, and an author of 1770 referring to the use of flour or meal for the purpose wrote, "Their hoarded grain contractors spare, and starve the poor to beautify the hair."

Any discussion of actual methods for hair dyeing is not to be found in the ancient records, probably because this was a trade secret of the beauty parlors. There has been a tremendous amount of fraud in connection with hair dyeing, as with all cosmetics and toilet articles. At times positively harmful materials have been employed, such as compounds of lead; lime, which acts destructively on the horny substance of the hair; and methyl or wood alcohol, which is poisonous and rather easily absorbed. The most effective hair dyes are those which form a precipitate practically coating or plating

the hair. Of course if an insufficient quantity remains upon the hair weird effects are seen, such as purple or metallic blue black gloss. Silver nitrate is sometimes employed and by drying in direct sunlight the black oxide of silver is produced. Potasium permanganate oxidizes to a brown color, the intensity depending upon the strength of the solution; and one homely formula consists in applying a water solution of the outer husks of the black walnut, which the small boy learned years ago will produce a decidedly black coloration of the hands.

In the East where eyebrows and eyelashes are often dyed India ink in gum Arabic and rose water is used. The coloring matter consists of finely divided carbon and so the dye is perfectly harmless. Another oriental formula depends upon changing the tannin bodies in nut galls into gallic and pyrogallic acids.

Three thousand years ago the Egyptians used henna and many other color-producing herbs for tinting their hair, eyebrows, and skin. In Persia, henna and indigo were used to produce a deep black color. Today the modern method, the henna pack, consists of applying the dye in the form of a paste which remains in contact with the hair from ten to thirty minutes. When it is considered that both the color and the texture of the hair are factors in this treatment, as well as the temperature of the air, it will be understood why hair-dyeing is really something of an art. If peroxide bleaching is used first, an expert hair dyer can produce almost any shade, partly by the skillful use of henna.

To be sure, the oil must be removed from the hair before any treatment, and further applications of dyeing material must be made according to the rapidity of the growth of new hair.

All things considered, it is evident that hair is far better left in its natural color.

PLATE ROLLING MILL.

C. L. HUSTON is the author of an interesting article in *Mining and Metallurgy* for January, describing the world's largest plate rolling mill.

Within the memory of Mr. Huston, the size of iron plates has advanced from a width of 26 inches, or even less, to 186½ inches in width. The old 26-inch plates were built up into boilers for the Mississippi River steamboats, while now the heads for great marine boilers can be made from a single piece. The article is illustrated by photographs of unusual apparatus and products including a large flanged head 183 inches outside diameter, 1½ inches thick, and containing three 49½-inch inside diameter flue holes. In addition to unusual mechanical equipment for which American mills are noted, accomplishments of this sort require a deal of science to make them possible. There are questions of heat control, of raw materials in the rolls and other parts of the unusual apparatus, and the composition of the ingots upon which the work is done.

When one considers the excellence of the mechanical appliances that have made the rolling of these great plates possible, it is but natural to hope the day may soon come when the scientific work applied to the steel industry may be said to have reached the same degree of perfection.

TRADING WASTES.

IN discussing the chemical progress of Germany, reference is often made to the formation of certain combinations which have made it possible for one plant to work upon the waste products of another, by which arrangement both plants were placed in a more advantageous position. Due to our anti-trust laws, it has been necessary for our corporations to be very careful concerning their relations and it is only occasionally that we find a chemical manufacturer so placed that he can invest in a second establishment so planned as to exchange its wastes for those of the older establishment.

One company which now manufacturers sodium carbonate proposes to engage in the fixation of atmospheric nitrogen and to use in its soda plant the surplus carbon dioxide of the nitrogen plant, the soda plant at the same time supplying to the nitrogen plant calcium chloride, which is a residue from the manufacture of soda.

The excess carbon dioxide is obtained as a by-product from the production and purification of hydrogen. These are produced in large quantities in the synthetic ammonia process. About 11 tons of carbon dioxide is obtained for every ton of pure hydrogen.

Carbon dioxide is much needed in the manufacture of soda and this is usually obtained from lime kilns, where limestone is burned with coal. By passing the carbon dioxide through heavy salt solutions the carbon unites with the sodium and forms bicarbonate.

A by-product of this process is calcium chloride, which thus far has been pretty much of a drug on the market. Under the new arrangement this sludge of calcium chloride will not be produced, but instead plants engaged in nitrogen and ammonia operations will get ammonia in a form suitable for direct application to the soil as a fertilizer. Indeed, ammonium chloride is considered as valuable as ammonium sulphate for this use.

The arrangement described should do much to reduce production costs, for there will be many tons of sulphuric acid saved, as well as great quantities of lime and coke or coal.

DRYING COAL PRIOR TO COKING.

WHEN the problem of producing coke with a low ash content from a high ash coal was solved, the problem of economically drying the coal remained. It was comparatively simple to apply the principle of the ore concentration table and recover cleaned coal from the tailing discharge. The coal washed in this manner comes from the conveyors with about 16 per cent of moisture and even a drying of three days' duration does not reduce this moisture more than 6 per cent. Sometimes the net result is a reduction of moisture to 8 per cent.

It is an interesting fact that water has been observed to flow out of the base of a bee-hive or by-product oven into which washed coal has been charged, and in the lower layers of such a charge a water content as high as 50 per cent has been observed. The water present has a highly destructive action on the walls of the retort and results in even greater losses in gas, oil, tar, and ammonia. Longer cooking hours are necessary, one-third of the tar and oil is destroyed, and it is estimated that 20 per cent of the ammonia is also lost.

It is seen, therefore, that drying the coal is highly important and experiments are now under way with a centrifugal dryer capable of treating 75 tons of coal per hour. This apparatus reduces the moisture to from 6 to 8 per cent, which is hardly enough of a reduction to excite enthusiasm. It is suggested that if the coal could be heated a better separation could be obtained. The question now seems to be whether it would be better to charge dry, warm coal into the coke retorts, and if by pre-heating the coal previous to charging it may be possible to make coke in 12 hours.

SODIUM VS. POTASSIUM.

THIS controversy grows out of the original availability of the two alkalis, potassium salts at one time having been more easily obtainable than sodium, caustic and carbonate. Later Germany was given a natural monopoly of potassium salts through the discovery of the Strassbourg deposits, and still later comparatively cheap electrolytic methods were devised for producing sodium hydroxide, soda ash likewise becoming plentiful.

The result has been that many of our textbooks continue to specify potasium as the only alkali with which many reactions can be carried on efficiently, and their methods require its use in much of the laboratory work. It was years before it was found that sodium cyanide was just as satisfactory for metallurgical operations as potassium cyanide, and of late much work has been done to show that most of the reaction essential to qualitative and quantitative analysis where alkalis

must be used can be carried out with equal satisfaction by employing sodium.

An instance worthy of emphasis is that of synthetic phenol, where according to the textbooks, in which statements of previous authorities are often taken at their face value without experiments to check their accuracy, potassium hydroxide must be used if satisfactory yields are to be obtained. This statement has been widely copied throughout the literature and is probably based on insufficient and faulty experimentation or carefully planned potash propaganda. In this country we were compelled to produce phenol during the war without potash and one of the companies assigned the problem to their research laboratory with the result that ways were found of obtaining just as good yields in fusing sodium benzene sulphonate with sodium caustic to produce phenol as could be obtained with potassium hydroxide. In large scale production ninety per cent of the theoretical yield was obtained, which is believed to be as high as yields attributed to potash. By very careful control yields of ninety-four per cent of that theoretically possible were obtained in experimental fusions, and two investigators found that by excluding air they could actually obtain ninety-nine per cent of the theoretical yield when using sodium benzene sulphonate and sodium hydrate. This process yields sodium sulphite as a by-product, which salt is employed in the purification of tri-nitro-toluol.

ORGANIC RESEARCH.

THE medical profession is greatly interested in anything that will increase the amount of fundamental organic research in the United States, and this requires improvement in the facilities for the manufacture of dyestuffs and other organic chemicals. We have really just begun to get results in that interesting field where chemistry and medicine meet and there is every reason to believe that further experimentation will lead to the discovery and utilization of new substances that will be of the greatest efficiency in the treatment of diseases. Chemotherapy needs an almost unlimited number of chemical compounds. For example, 605 organic compounds were tried out before Salvarsan, "606," was found. This compound can no doubt be improved upon, but it requires the development of new compounds for the purpose. Veronal, a drug much used to produce sleep, procaine (nevocaine), which is the monohydrochloride of paraamidobenzoyldiethylamidoethanol; are the results of organic research. Luminal is said to be better than veronal, but it is not yet obtainable in this country. Quinine may be made synthetically while chloramine T and similar new compounds have become of great value in treating infected wounds. In practically all instances where American chemists have undertaken the preparation of these complex compounds they have produced highly satisfactory material at lower cost than had been paid before the war. Indeed it had become the custom abroad to make a few specialties pay for all of the other compounds produced as by-products in the synthesis and therefore to carry the burden for the whole series of compounds, leaving the others to yield the net profits. We surely cannot afford to be without every facility for research work of this character.

CHINESE DYES.

SO MUCH has been written and said concerning synthetic dyes that many have forgotten the fact that a large number of important colors are still derived from the vegetable kingdom. The following statements with reference to the native dye industry in China are taken from the *Color Trade Journal*, Vol. VI, No. 2, February, 1920:

Just before the outbreak of the war German synthetic indigo was imported into China to the extent of 10,000,000 taels a year, in addition to a large quantity of German aniline dyes. These had replaced in great measure the native vegetable dyes in which China was so rich; in fact, indigo was no longer regarded as one of China's agricultural products. The native dye industry, however, by force of circumstances, has been revived, and dyes are now appearing in the list of exports.

Of first importance is indigo. It is grown quite generally throughout China for local purposes, but assumes greater importance in trade in the south. It appears that one acre of ground will produce about 6,000 pounds of indigo. According to tests made by the United States Bureau of Foreign and Domestic Commerce, the Chinese indigo contains only about 1 per cent of pure indigo. Thus an acre will produce, with a good crop, about 60 pounds of pure indigo. The plants are cut before flowering, steeped in cold water for some days, and well stirred. After the plants are removed the water is again stirred, and slaked lime added to precipitate the dye. In 1917 China exported 78,148 piculs (picul equals 133 1/3 pounds) of liquid indigo, valued at $700,000. In 1918 the figures were 83,642 piculs, valued at $900,000. Kiukiang and Swatow are the principal ports of export.

Yellow is produced from the flower buds of the locust tree (*Sophora japonica*), which are baked to a light brown color, placed in cold water, and brought to the boil. Alum is used as a mordant. The powdered roots of *Curcuma longa*, or tumeric, are also used for a yellow dye, especially for cotton fabrics.

Red is produced from safflower, grown in Szechwan. Balsam (*Impatiens balsamina*), *Anchuse tinctoria*, and *Lawsonia alba* are also used, the latter to produce the rouge used by women. The *Rubic cordifolia*, a creeper, is used to make a deep red.

Green dyes for cotton cloth are produced from the bark of the *Rhamnus parvifolius*, found in Szechwan. Green dye is also made from the leaves of the *Rhamnus tinctorius* and other species of the buckthorn.

Brown dye is produced from the false gambier, grown extensively in southwestern China. The darker browns are produced by the addition of gall-nuts and alum. A brown cloth that is very popular in the summer with the Chinese is a dyed grass-cloth with a bright lustre and a waterproof appearance. Its distinctive qualities are the result of the dyes made from the false gambier.

The vegetable dyes of China are particularly well suited to Chinese rugs. These dyes will outlast the rugs. Exclusive of indigo, China exported nearly 2,000 tons of dyestuffs during 1917.

ASBESTOS PAPER.

IN *Chemical and Metallurgical Engineering*, issue of February 4, 1920, is an abstract on the history of asbestos paper based on investigations at the Bureau of Mines. It seems that asbestos was used by the ancients for winding sheets, table cloths, and similar fabrics. It was a woven and not a felted product, and therefore, is not to be confused with asbestos paper. One of the earliest references to asbestos paper was published in 1750, and it would seem that the primary object at that time was to obtain an indestructible writing paper, although the report states that while the paper did not burn, the writing disappeared. One hundred years later further efforts were made with the same object. In 1853 a patent was issued for a process for making asbestos paper and many experiments have been made to produce suitable asbestos printing paper. Asbestos paper, however, is not well adapted for printing and writing because it does not have a smooth surface and in absorbing ink, behaves more like blotting paper. Therefore some of the papers have contained but small quantities of asbestos, the remaining fibres being combustible, but upon burning a white residue, which maintained its shape and preserved the written characters, would be found.

Asbestos paper has also been used for ornamental wall paper and carpet linings and during the last twenty-five years new uses have dominated its production. At present some plants manufacture as much paper in a single day as was produced annually twenty-five years ago. In addition to paper, mill boards of various thicknesses have also been produced and the chief uses of these products are insulation, roofing, building, paper lining for stoves, air cell pipe covering, high pressure gaskets, and packing.

Progress in the Field of Electricity

Summaries and Excerpts from Current Periodicals

ELECTRIC HEATING AND COOKING.

THE scarcity and high cost of fuel are giving a great impetus to the movement of the electrical industry for the complete "electrification" of the home and the factory. Of timely interest is, therefore, the report made by Dr. K. Norden to the Society of German Electrical Engineers, which report was read at their annual meeting on September 27, 1919 (*Electrotechnische Zeitschrift*, October 16, 1919, Vol. 40, page 518-20). Dr. Norden discusses the status of the electric heating of the home and of the industrial plant, of electric cooking and of electric heating in various industrial processes, his conclusions being based on conditions in Germany.

The heating of the home by electricity on a general scale does not seem to be possible of realization in the nearest future. It would necessitate first a low rate for power; for instance, in order to compete even with the present high prices of fuel in Berlin, the electric power would have to be sold at 4.5 pf. per k.w.h. Again since electricity is first applied in those fields where its present cost is justifiable, namely, for lighting and motor energy, it is evident that only that amount of energy which is left over in the central station would be available for home heating. Granting that both—a low rate for power and a great reserve of energy are available—there still remains the question of the additional distribution circuits and line apparatus.

On the other hand, the heating of industrial plants by electricity can be introduced in the nearest future, for the relative amount of energy required is much less and, furthermore, almost each and every plant is either connected to a high pressure feeding line or has a power-plant of its own. However, in order to be successful, the introduction of electricity as a source of heat will have to be based on the principle of heat accumulation or storage, which principle would allow the use of the electric current for heating purposes during the non-rush period or idle hours—like the lunch hour, etc. In this connection it must be stated that the electrical engineer must devote himself to the serious study of the principles and technique of the science of heating and ventilation if he is to introduce successfully electricity as a source of heat. Special courses should be given in the electrical engineering colleges while the older generation should avail itself of extension courses on this subject. The theory of heating presents also a very interesting subject for further industrial research.

The modern factory may be heated electrically direct by separate stoves scattered throughout the plant, or by central heating stations providing hot air, steam or hot water heat, which stations would use electric energy as a source of heat. If the direct method of heating is used the conventional stove having for its heating unit a resistance wire wound on a porcelain base will have to be discarded: its life is short and its surface temperature too high; therefore it is unhygienic and may cause fires. The heating element should be more accessible to the air, and the temperature at its surfaces should not exceed 100°. Again the electric stoves will have to be built on the principle of heat storage; the heat absorbing element may be either a liquid or certain minerals or use may be made for this purpose of the heat of melting or of the heat of chemical dissociation.

The central electric heating station is quite feasible, and reliable equipment has been offered by the German manufacturers. The boilers of such installations are to be built in such a manner as to allow of their operation either in the usual manner or on the principle of heat storage. For the present it is hardly advisable to discard entirely the coal burning equipment; the latter should be used entirely during the very cold period, should be supplemented by electric heating during the moderate weather, while only electric heating should be used for intermittent operation or during cold spells of short duration.

While Mr. Dettmar discussed the possibilities of electric cooking as far back as 1911 it has made but little progress in Germany. This must be met by a strong publicity campaign accompanied by opening of free schools for electric cooking; the technic of the electric kitchen has been improving, but much has to be accomplished as yet. The greatest obstacle, the high rate of consumption of energy, must be eliminated by the design of an electric heat box or a stove built on the principle of heat storage.

As to the electric heating of apparatus used as machines or tools in various industrial processes, its advantages have been known and quite well understood. The methods of control are accurate and reliable; only the needed amount of heat carefully measured is introduced and all utilized; the installation is less complicated, cheaper and takes less space than in the case of steam or gas; especially is this true for machinery in motion.

The immediate need is a thorough standardization of all apparatus used in connection with electric heating and cooking. In many cases numerous types of the same appliance exist which could be reduced to several most convenient sizes. The same holds true of various machinery electrically heated. In order to succeed the electrical engineer must seek the cooperation of the designers of such machinery.

ELECTRIC FURNACE DEVELOPMENT DURING 1919.

DURING the war a great impetus was given the electric furnace for steel manufacture. After the armistice had been signed there seemed to be some question as to whether the use of the electric furnace would be extended as rapidly as indicated during the period of war. However the electric furnace has been easily holding its own, many customers frequently specifying electric steel for more important work.

At the expiration of the year just passed approximately 850 electric furnaces for the production of steel were in use throughout the world, about 375 of which were located in the United States and Canada. Some 20 different concerns manufacturing or selling various makes of electric furnaces are at present in the American markets, this is an increase of perhaps 5 over the year previous. During the year approximately 45 electric steel-making furnaces were either placed in operation or contracted for in the United States and Canada.

The tendency has continued during the past 12 months to further increase the manufacture and sale of polyphase furnaces of arc type. The use of single phase or induction furnaces, especially in larger sizes, has been practically abandoned by steel makers. Opposition to the latter two types is due to their unfavorable operating efficiencies and to the unsatisfactory load conditions which they produce on power circuits. A number of minor changes have been recently made in the mechanical and electrical designs of electric furnaces. Less complicated mechanisms for tilting and better facilities for changing roofs, relining, charging, slagging, pouring and speeding up the furnaces have been adopted. Furnace electrodes are said to be of better quality than those formerly available, but little improvement has been noted in the refractories used for furnace linings.

The demand has been mostly for furnaces of capacities not greater than 15 tons; it seems that the small sizes are able to show marked economies, furthermore, many purchasers prefer to make their initial investment in smaller sizes so as to try them out before tearing away their fuel burning furnaces. In comparison with the crucible furnace, the converter and the small open hearth furnace many users concede the cost advantage to be in favor of the electric furnace. Some manufacturers of tool and special high-speed steels contend, however, that the product of the crucible cannot be equalled by the electric furnace. Whereas this contention may possibly be open to question, the fact that many other crucible plants are now using electric furnaces goes to show that this opposition is gradually disappearing.

Considerable discussion has taken place during the year regarding more extended, new and heretofore unthought of uses of the electric furnace. The application of the duplexing process whereby steel is preheated in the converter or open hearth furnace and later refined and superheated in the electric furnace, has been further developed. In fact several new installations of this sort have been made during the year. A number of experiments have been made in the use of the electric furnace in gray iron and malleable foundries. Where especially sound and fine cast or malleable irons have been needed for pouring light or thin section castings, this application of the electric furnace has exceeded expectations. It is well known that by ordinary means of production considerable phosphorus is required for making gray iron or malleable castings, in order to secure the proper degree of fluidity. As any desired superheat may be obtained in the electric furnace, iron much lower in phosphorus content may be used, and greater strength and toughness in the castings may be attained.

Much desirable datum is yet to be gained and collected on physical tests of electric steels. Some valuable information of this sort has been collected by the Electric Furnace Association. The association was formed during the past year. Its membership is open to makers of electric furnaces and their auxiliary equipment, as well as to those directly interested in the products of the electric furnace.—From *Blast Furnace and Steel Plant*, January, 1920.

AUTOMATIC SUB-STATIONS.

THE rapid progress which is being made in the adoption of automatic sub-stations is indicated in a recent report of the Committee on Power Generation presented at the convention of the American Electric Railway Engineering Association at Atlantic City, N. J., and abstracted in *Power*. While the principle is not new, and installations were known where the rotary transformers were placed in unattended sub-stations, and with the batteries controlled from the generating station, yet it must be admitted that these were only semi-automatic. The present-day installations, on the other hand, are entirely automatic, going on load when the demand calls for it, and switching themselves out when the load falls off.

The first automatic sub-station control was put into operation as recently as Christmas, 1914. In 1917 the first installation involving the operation of two synchronous converters in series was made, and in 1918 two synchronous converters were first automatically operated in parallel. Four and one-half years after the first experiment was made there were 35 full-automatic and two semi-automatic, or remote controlled sub-stations in actual operation and in addition 31 automatic and four semi-automatic equipments stood on order with manufacturers. Rotary converters as large as 1,000 k.w are handled automatically, while a 2,000 k.w. motor-generator is about to be put into service, and a 3,000 k.w. synchronous condenser is running. It is clear that the system has proved successful.

The first automatically-controlled water wheel generating station, which contains three 500-k.w. generators arranged to operate in parallel either under the influence of full-automatic control at the generating plant or controlled if desired by an operator in the main steam-generating station at a distant point, was put in operation in 1918. The success of this installation makes possible the development of a considerable number of small water powers that otherwise could not be developed because of the cost of operating labor. By using asynchronous generators the difficulties of speed regulation and synchronizing can be overcome, and the control reduced to its simplest terms.

Several companies have chosen automatic equipment in consideration of saving in labor. The largest figures received gave an estimated saving of $400 per annum on a 300 k.w. station and $700 on a 500 k.w. station. One company installed a 250 k.w. automatic station to replace a floating battery between two sub-stations ten miles apart, in preference to spending $5,000 for necessary repairs to the battery. When some of the automatic sub-stations were built in new locations, however, it was in several cases possible to remove feeder copper which possessed a value sufficient to offset in part the cost of construction of the sub-station building with its equipment. In an exceptional case the cost of construction of a two-unit sub-station containing two 300 k.w. synchronous converters was more than offset by the value of the feeder copper that was removed from the distribution system, and a more satisfactory line voltage was maintained on the line as a whole. The most notable saving of copper was made in Des Moines where, through an installation of a system of automatic sub-stations, an amount of feeder copper was taken down which was worth $90,200, and at the same time a sub-station and distribution system were obtained which cost according to estimate $141,700 less than an equivalent system to give the same voltage regulation would have cost, had additional manually operated synchronous converters been placed in the central power station and additional feeder copper put up on the outside lines. The example is somewhat unusual but is given here to illustrate the possibilities that are offered in not a small number of cases.

It was brought out in the discussion on this report that at the present time the economic limit in automatic sub-station capacity is about 6,000 k.w.; above this limit it is more economical to install manually operated equipment.

USE OF ALTERNATING CURRENT FOR TELEGRAPHY.

THE shortage of batteries and their high cost in Europe induced French and Swiss engineers to experiment with alternating current as delivered by the ordinary industrial circuits, as a possible source for the telegraph apparatus. The experimental section of the French postoffice has conducted elaborate tests at its Brest station. This installation has given such satisfactory service that it is proposed to apply alternating current in the main telegraph centers.

A complete and illustrated description of the above installation is given in *Annales des Postes, Télégraphes et Teléphones*, Vol. 8, September, 1919, p. 446-461, a good summary of which also appears in the *Technical Review* of London.

The alternating supply is taken from three-phase mains through a bank of transformers. On the secondary side the current is rectified by a mercury vapor rectifier with three cathodes. A buffer battery is connected between the neutral point of the secondary windings of the transformer and the cathode of the rectifier. Between the battery and the rectifier lies an automatic switch, which disconnects the rectifier leads if the current changes its direction owing to a drop of voltage across the rectifier terminals, and reconnects the rectifier to the battery when the voltage rises again. During the period of disconnection the Morse, Hughes and Baudot telegraphic apparatus is supplied by the buffer battery alone. A red lamp signals this state of affairs, and if the attendant ascertains that it will last for a prolonged period he prepares a reserve battery of cells for use. This reserve battery is always availa-

ble for use but the cells are kept dry until an emergency arises.

In order that the arc of the mercury vapor rectifier may not become extinguished when the call for direct current falls below the minimum value that will maintain the arc, a permanent shunt taking from 1.5 to 2 amperes is connected between the cathode and the neutral point of the transformers. Normally the battery voltage is slightly lower than the rectifier voltage, so that the battery does not discharge, but is slowly charged.

If a motor generator set were used to replace the local batteries of the Baudot sets, it could be driven by a direct-current motor connected to the buffer battery. This would simplify the above-mentioned arrangement by rendering the permanent shunt unnecessary, and this would render current reversal impossible and permit the automatic switch to be dispensed with.

ELECTRIC LOCOMOTIVES FOR INDUSTRIAL PURPOSES.

THE electric locomotive has attained a well established place in our everyday commercial and industrial life. The rapid and efficient transportation of material in all lines of industry is becoming more important every year.

There are three general forms or types of locomotives, viz.: straight trolley, straight storage battery and the combination of both storage battery and the trolley. Each type has special merit and points of advantage according to the conditions under which it is required to operate.

The trolley type is the original and thoroughly proved type and is more common one in use for all purposes, particularly in mining service, but owing to the disadvantage of having trolley wire or collector rails around industrial plants, it has never been adopted to the extent that would be expected in view of the demand for electric locomotives for such service. Wherever the conditions permit using the type with safety, and particularly where the haul is long and loads heavy, it is the logical one to use. In many cases special forms of collector rails and other devices can be used which largely remove the danger to workmen, but where safety considerations are paramount and where fire risk is an important factor the storage battery type is better adapted. The motor capacity is much greater than for storage battery types: at operating speed the draw-bar pull is based on an adhesion factor of 20 per cent of locomotive weight with chilled cast iron wheels on clean dry rail. With steel-tired wheels this is increased to 25 per cent. For starting, an adhesion factor of 33 1/3 per cent with the use of sand on the rail is permissible. The motor equipment in all cases produces tractive effort sufficient to slip the driving wheels, thus providing protection against injurious overloads. For all conditions except heavy high-speed freight service the two-motor equipment with single reduction gearing is used, having a speed of 6 to 8 miles per hour under full load.

A modification of the trolley type designed to handle freight cars at the ore docks is called the "pusher" type. The car tracks run directly under the ore shutes, and the locomotive track is placed between the regular tracks. The push poles operated by air extend out on each side and can be raised to a vertical position when not in use. To move cars the pole is dropped between the end sills of two coupled cars of a train, pushing cars or retarding same as desired; it is equipped with steel cable and hook attached to front end for pulling cars out of reach of push pole. One of the chief advantages of this method of handling cars is the fact that the locomotive can control cars on two tracks at one time, spotting cars on one track, while the cars are being loaded on the other. In addition to this the motorman is in position to see when cars must be moved, or to receive signals direct from the main operating ore dump.

The main characteristic of the storage battery locomotive is the storage battery itself. Fortunately, it is today produced in a form which withstands the most severe mechanical strains caused by the rough operating conditions usually encountered, and from an electrical standpoint operates efficiently both in regard to cost of power and maintenance. The design of the motor and of the auxiliary electrical equipment have been brought to an equally efficient plane. This has resulted in the production of high-speed motors driving through double reduction gearing, designed for running on the minimum voltage considered practical, and having a low current rating which makes it possible for the daily cycle of operation in many cases to be performed with one charge of a battery such as can be applied to a locomotive of reasonable dimensions. In addition to this methods of control are used which enable the motors to be accelerated with a minimum amount of current wasted through the resistance. The mechanical design has kept pace with the electrical equipment now available, resulting in light weight but thoroughly reliable locomotives.

The next important consideration is the selection of the storage battery, with special reference to the cycle of operation required for the period of the average working day as well as the weight of the loads to be hauled. Owing to the fact that the battery has a limited amount of energy, the work it will perform depends in large measure upon the rate at which it is called upon to deliver this energy. The speed of storage battery locomotives is necessarily slow and the character of work performed is not such as to require high speed.

It is quite difficult to standardize storage battery locomotives. The three sizes given below have been found to satisfy most of the industrial or mining requirements:

Nominal Wght. of Chassis, lbs.	Nominal Drawbar Pull, lbs.	Nominal Speed, m.h.p.	—Motors— Voltage	Total h.p.
6,000	1,000	3.5	30	11
8,000	2,000	3.5	80	23
10,000	3,000	3.5	80	32

Storage battery locomotives of larger type have been built but without any attempt at standardizing to the same extent. The tendencies are towards large batteries and increased motor capacity, and towards a slower speed motor suitable for operating with an efficient single reduction gearing.

The combination trolley and storage type can be used only where conditions warrant. The added flexibility to be gained by the storage battery is important in covering a large area with a minimum expenditure for overhead construction as well as offering a solution for combined indoor work where trolley wire would be prohibited with outdoor work where loads and length of haul might be beyond the capacity of a reasonable sized battery, without frequent recharging or changing of batteries. The battery is charged while locomotive is operating on the trolley thus saving time.

The chief disadvantage is the difficulty of applying a battery of necessary capacity without exceeding the permissible weight for the motor equipment, however, where the period for battery operation is short compared with that for trolley operation the battery capacity can safely be much smaller than would be the case for straight battery operation.

Comparing the electric locomotive with his nearest and commonest competitor—the steam locomotive—it is found that the former is more desirable. While the initial cost of the two types is about the same the maintenance and operating costs are greatly lowered and of a definite value in the case of the electric locomotive. It requires a minimum of repairs, the fuel is used very economically and the fireman is eliminated. It is figured by many industrial plants that the electric locomotive pays for itself in from three to four years.—Walter Fixter and Kenneth Andrew. Association of Iron and Steel Electrical Engineers, November, 1919, pp. 9-34. *Journal of the Engineers' Club of Philadelphia*, January, 1920.

Survey of Progress in Mechanical Engineering

Prepared Under the Auspices of the American Society of Mechanical Engineers

BLAST ENGINE WITH REACTION JET PROPULSION.

At the recent Paris aeronautical show there was exhibited a trial machine embodying the Mélot principle of propulsion. It is stated that the inventor experimented during the war at the Laboratoire du Conservatoire des Arts et Métiers in co-operation with the French Ministry in Munitions.

The machine consists of a burner with fireproof lining. Into this an explosive mixture is injected and ignited in the first instance by a spark plug, after which combustion continues uninterruptedly. The burned gases are exhausted through a blast pipe and four blast "engines," which are really graduated nozzles, one large and three small.

At the inlet mouth of each of these nozzles air is drawn in by suction, and the whole mixture of air and burned gases is

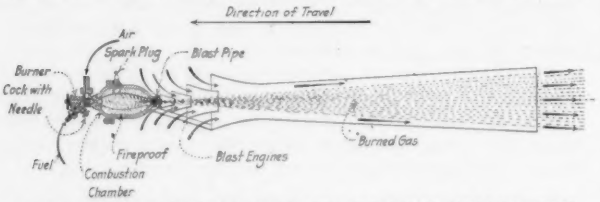

FIG. 1. MELOT SYSTEM OF PROPULSION FOR AERONAUTICS

exhausted by the last and largest blast engine and makes a direct thrust against the air at the rear of the engine (Fig. 1).

The machine is said to give 30 h.p. for a relative speed of 50 m. (164 ft.) per sec. The weight per horse-power is said to be 0.5 kg. (1.1 lb.), and it is obvious that if the machine is capable of functioning for any length of time, its cost ought to be quite low because of the absence of valves, pistons and other parts of the conventional engine.—*Aeronautics*, Vol. 18, No. 331 (New Series), Feb. 19. 1920, p. 157, 2 figs.

DOES PICKLING AFFECT THE QUALITY AND MACHINABILITY OF STEEL?

By H. L. Hess, Mem. Am. Soc. M. E.

Pickling is extensively used, as it facilitates the discovery of seams and surface defects generally, and removes all furnace and rolling scale. Various solutions are used, such as highly diluted baths of sulphuric or hydrochloric acids.

A series of tests were carried out by the metallurgical department of the Hess Steel Corporation, Baltimore, Md. In these tests 1 lb. of a special pickling compound (not otherwise specified) was dissolved in 3 gal. of water, and the mixture held at a constant temperature of about 200 deg. fahr. The tests were made on round pieces (1½ in. in diameter and 3 in. long) of chrome steel with approximately one per cent carbon and 1.50 per cent chromium.

As the object was to determine the lasting effect of the pickling on the metal, various subsequent treatments were used in order to neutralize fully or partly the effect of the pickling, the pieces being washed in cold, hot or lime water and tested either immediately or after periods varying from 7 to 28 days. The tests were made for hardness without cleaning, polishing or filing the surfaces in any way previous to the test, this being done in order to avoid the possible removal of a skin which might have appeared as a result of the pickling.

On the whole it was found that the hardness results do not seem to be affected by the pickling treatment, although there was a slight indication that the unpickled steel has a somewhat softer surface than the pickled specimens.

Careful machining tests showed absolutely no difference in machinability, and it would appear that pickling affects only the skin, and even that to an effect not noticeable in machining.

Further tests were made to find out, if possible, whether pickling would have any effect upon the surface of the material and whether this effect were traceable to any appreciable depth. In these tests each piece of steel was subjected to a careful microscopic examination of the surface before and after aging and at various magnifications. The photomicrographs do not show any distinct difference between the pickled and unpickled bars.

The general conclusion drawn from these tests is that pickling in itself, as well as pickling followed by various treatments, does not interfere in any noticeable way with the quality or machinability of the steel.—*Iron Age*, Vol. 105, No. 9, Feb. 26, 1920, pp. 593-594, 6 Figs.

PRESENT STATUS OF THE CONCRETE SHIP.

The original program of concrete-ship construction of the Emergency Fleet Corporation was reduced after the armistice to a total of fourteen vessels, and in October, 1919, contracts for two 7,500-ton cargo-vessels were cancelled.

At the present date there are in service three 3,500-ton cargo vessels and one 3,000-ton cargo vessel, three 7,500-ton tankers and twenty-one 500-ton canal barges built by the Railroad Administration under the supervision of the Emergency Fleet Corporation. The remaining vessels are in various stages of completion and are expected to be in commission by next summer.

In general, it is stated that in carrying out this program no construction problems were encountered which were not successfully met. The experience of the vessels in service thus far indicates that for cargo vessels there is ample structural strength, and that the barge is a much simpler problem in concrete than in usual materials.

On the other hand, it was not found that reinforced-concrete hulls could be built with greater speed than steel hulls, the average time of constructing the concrete hull being seven months.

In service concrete ships stood up quite well. In fact, there is generally less vibration in concrete ships than in corresponding steel ships, and also a considerable increase in the period of roll, which is desirable, and is apparently due to the fact that these vessels have a larger moment of inertia around the longitudinal axis than steel ships, because the mass of the concrete shell is considerably greater than the mass of the shell in a steel ship.

On the other hand, experience seems to indicate that these vessels are unable to withstand severe concentrated blows on the shell without the shattering of the concrete.

Impact, which in the case of a steel ship would probably only cause indentation of the plates, in the case of the concrete ship is apt to cause a shattering of the concrete over the area adjacent to the point of impact.

Repairs, especially in the case of barges, are, however, relatively simple and can be effected with little loss of time and at small cost.

The dead-weight capacity of the concrete ship was found to be lower than expected, the actual ratio of dead-weight displacement being on the average little more than 0.50. Furthermore, in the case of a steel ship and a concrete ship having the same dead-weight capacities, the concrete ship

because of the greater weight of the ship itself must have greater dimensions than the steel ship, and in consequence must have greater hold spaces. For heavy-weight cargoes such as steel, coal or oil, in which the dead-weight capacity is reached before the hold spaces are filled, steel has obviously an advantage over concrete as a material of construction, assuming that construction and operating costs are equal. For bulky cargoes, such as ordinary goods, cotton, fruit or other materials for which the space required exceeds about 70 cu. ft. to the ton, the concrete ship will actually carry more dead weight than the steel ship for the reason that the hold spaces of the steel ship will be filled before dead-weight capacity is reached.

The report expresses the opinion that no definite conclusions should be drawn as yet from the experience of these vessels; and that the only general conclusion therefrom seems to be that it is possible to construct ships of concrete in about the same time, and for approximately the same cost as corresponding steel ships, which would indicate that with more experience in the art it will be possible to reduce both the cost and the time for construction. As regards the length of life of concrete ships, no sufficient data are available, and the brief experience of vessels afloat has disclosed no serious inherent weakness to shorten the life of a concrete ship.—Report read at the Convention of the American Concrete Institute, at Chicago, Feb. 16-18, 1920, by Committee on Reinforced Concrete Barges and Ships, H. C. Turner, Chairman. Abstracted through *Engineering News-Record*, Vol. 84, No. 10, March 4, 1920, pp. 463-464.

INVESTIGATION OF MUFFLING PROBLEM FOR AEROPLANE ENGINES.

By G. B. UPTON and V. R. GAGE, Members Am. Soc. M. E.

DATA of tests carried out under the auspices of the National Advisory Committee for Aeronautics on a Curtiss aeroplane engine and several stationary and other engines using a fan dynamometer.

The paper describes in considerable detail the methods of measurements and the formula used. As regards the relation

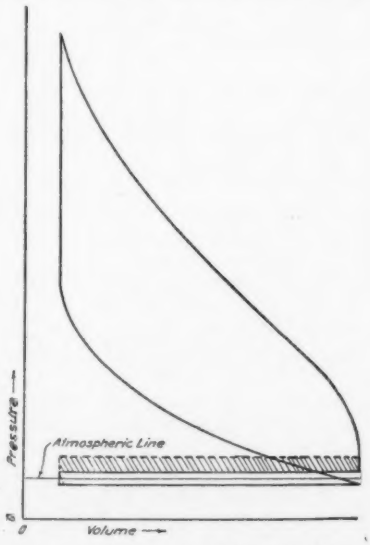

FIG. 2. INDICATOR DIAGRAM SHOWING LOSS OF POWER THROUGH BACK PRESSURE AT EXHAUST VALVE

between back pressure and power output, it appears to have been found that for moderate back pressures, the power loss is substantially proportional to the back pressure, while for higher back pressures the power loss amounts rapidly, apparently at such a rate that a back pressure of even less than 10 lb. per sq. in. would stop the engine.

A possible explanation of this changing effect of back pressure as the back pressure increases may be found by considering the indicator card. This is schematically shown in Fig. 2. For small back pressures we may expect the main effect to be a lifting of the exhaust line of the card by an amount substantially equal to the increase of back pressure. The result would be a loss of indicated mean effective pressure equal to the back pressure, because the elevation of the exhaust line would extend through the whole stroke. The loss of brake mean effective pressure will be smaller than the loss of indicated mean effective pressure in the ratio of the mechanical efficiency of the engine to unity.

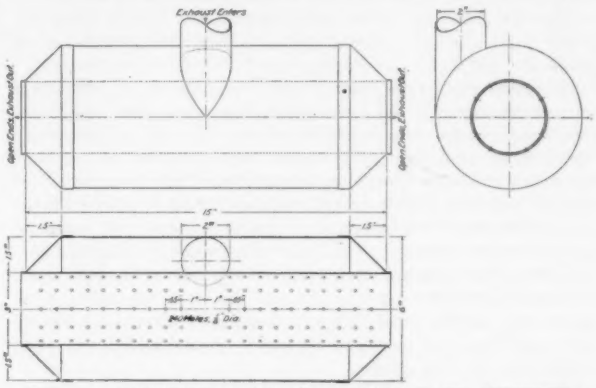

FIG. 3. TANGENTIAL-WHIRL-CHAMBER TANK MUFFLER RECOMMENDED BY THE NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS FOR THE LIBERTY AIRPLANE ENGINE

At higher back pressures the exhaust gases are held back in greater amounts in the cylinder, leaving the clearance space, at the end of the exhaust period, filled with an abnormal weight of hot, dead gases. These re-expanding, interfere with the incoming charge in various ways, lessening the amount of the fuel mixture drawn in. The decrease of charge quantity will result in a decrease of the mean effective pressure which is added to the decrease of mean effective pressure due to lifting of the pressure of the exhaust line.

Probably it is the decrease of charge which is the principal reason for the possibility of stalling the engine by fairly completely choking the exhaust pipe and before complete closure is reached.

It was also found, as regards the relation between the brake horse-power and the actual back pressure, that "the back pressure increases as some exponential function of the horse-power, when the conditions of the exhaust passages remain unchanged." [Quoted literally.—EDITOR.]

Data are presented to demonstrate that the choking of the exhaust by sharp turns, pipe fittings, etc., gives the same results as choking by a muffler.

In the course of the experimental work carried out some peculiar phenomena were noted. One such was the abnormal power drop, considering the back pressure, at certain critical speeds. It was found that this abnormal power loss could be avoided by a very small change of speed either way from the critical.

The critical speed changed or disappeared with change of exhaust manifold. The supposed cause of this abnormal power loss at the critical speed is a reflected wave of exhaust gas killing the clearance of some cylinder just before its exhaust valve closed.

A number of mufflers was tested.

The authors recommend a tentative design for the Liberty 12-cylinder engine, that shown in Fig. 3, where air is supposed to pass through the inner tube to some extent aiding in cooling.—*National Advisory Committee for Aeronautics*, Report No. 55, preprint from Fifth Annual Report 1919, 38 pp., 27 figs. and numerous tables.

OZONE AIR CLEANING.

By E. S. Hallett.

Description of installations tested out in the public schools of St. Louis, Mo. The Head of the Hygiene Department of the Board of Education of St. Louis came to the Building Department with the complaint from one of the downtown schools that the air was so bad in some rooms that teachers threatened to resign on the advice of their physicians. The writer proposed to the Hygiene Department to test the application of ozone.

The ozone apparatus was set up in the air passage between the air washer and fan, and regulated to produce just sufficient ozone to be barely detected by the odor on entering the building, but not enough to make one conscious of an odor. The result was the actual disappearance of all the stuffy conditions and bad smells complained of. The teachers stated that the conduct of the children as to lessons and behavior was noticeably better. Colds and coughs nearly disappeared. No contagious diseases developed during the six weeks' trial, although the influenza was epidemic at this time. In fact, during the period of an influenza epidemic, the attendance in this school was 30 per cent higher than the general average attendance for this school.

The experiment was then transferred to a colored school having the plenum system with the Zellweger air-washing fan and with complete recirculation of the air. The ozone machine was set up just back of the fan, the ozone acting upon the water of the air washer as well. In this test the pupils and teachers were weighed weekly and a close inspection made by the staff physician of the Hygiene Department. About 75 per cent of the children gained in weight on an average of about one pound, about 5 per cent lost weight, while the rest suffered no change. Several very stout girls weighing about 170 lb. each lost from 5 to 8 lb. weight (total duration of test not stated). No indication of illness or discomfort was noted. No contagious diseases occurred in this school and colds were noticeably less.

The coal consumption was measured, and in comparison with days of equal outside temperature the coal used was almost exactly one-half.

Agar plates were exposed in a room filled with pupils and showed an average count of bacteria of 225, which was extremely low, indicating that the ozone had destroyed the active germs of the air.

These and other tests during a year's period indicated that ozone destroys all odors resulting from the respiration, bodies and clothing of the children, and produces a mild exhilaration resembling that of a sea breeze or the air on a morning after a thunderstorm. It appears from limited data to be a preventive of influenza, and it is believed that its introduction in ventilation would probably remove the necessity for open-air schools now common in most cities.

The maximum concentration should be too low to give an ozone odor, and if used up to this concentration is safe for ventilation. Persons not used to ozone in air must be employed for detecting the air, as the sense of smell for ozone quickly declines when exposed to it.

The writer developed a standard which may be used in determining in advance the proper concentration for any given volume of air movement or for a given number of occupants in a room.

This standard was developed after ascertaining that with a given voltage and with a given thickness of dielectric the amount of ozone generated was proportional to the number of brush discharge points of the generator.

The most satisfactory apparatus uses 4,000 volts alternating current from a static transformer, all included with the ozone generator unit, which uses a micanite plate dielectric 0.040 in. thick and aluminum points spaced approximately ½ in. apart. It was observed that 600 brush points made just enough ozone for 1,000 cu. ft. of air from the blast fan.

This test was with rooms filled with 45 to 50 children much below the average in cleanliness. For rooms occupied by fewer people, the brush points or voltage should be reduced. If conditions are to remain constant, some points should be disconnected, but with varying conditions a controller should be installed to regulate the voltage by taking taps out of the primary of the transformers.

Where the air is recirculated in whole or in part, the ozone must be cut down to the point where no ozone odor is noticeable. In fact, the revitalizing of the air of the average school room when recirculating 90 per cent of the air will be effectively done with half the maximum stated above. The writer believes that the delay in the use of ozone in ventilation has been due to trials made with too high concentration and to the absence of any information on a means of control.

The writer proceeds to show a heating system designed in the light of these tests. It has no air washer.—Paper presented at the Annual Meeting of the American Society of Heating and Ventilating Engineers, Jan. 27-29, 1920, under the title, "An Advance in Air Conditioning in School Buildings." Compare *Heating and Ventilating Magazine*, Vol. 17, No. 2, Feb., 1920, pp. 25-29, 1 fig.

POTS AND BOXES USED IN CARBONIZING.

By H. H. Harris.

While heat-treating furnaces and processes have been consistently developed in the last score of years the pots and boxes used in the cyanide and lead-hardening processes have changed very little.

The factors govern the service received from pots and boxes. They are—design, method of manufacture, and material. As regards design, the author states that while in some plants there have been considerable improvements, through the industry at large a great majority of carbonizing boxes are of a design as well adapted for packing soap as they are for carbonizing, which affects the results obtained in a very undesirable manner.

To be good a box must be designed to permit tight sealing with some refractory or other material, in such a manner, however, that the clay should not enter the box and mix with the compound. Proper dimensions of the box are also important. The thickness of the box should be light enough to prevent warpage and still sufficient to permit proper flow of metal in the casting.

Materials for pot and box manufacture may be grouped into six classifications: Cast iron, cast steel, pressed and rolled steel, "trick" materials, alloys and materials calorized.

Cast iron is both the cheapest first-cost material and the poorest. It oxidizes rapidly, gives a non-uniform service, becomes distorted easily, forms scale which mixes with the carbonizing compound and is likely to spoil the work, and finally is affected by the cyaniding mixtures.

Cast steel is generally much superior to cast iron. It costs about twice as much per pound, but may give much longer service. The principal objection to cast steel is that the grade of steel used for pots and boxes is usually of inferior quality, sometimes even semi-steel being offered for steel. The method of casting the pots and boxes is also often unsatisfactory.

Judging, however, from the average of various types and conditions studied in many of the largest plants in the country, the author does not believe that any material has shown on the average a uniformly longer life per dollar invested than cast steel with the exception of a nickel-chromium alloy which he refers to as "Q-alloy."

Pressed- and wrought-steel pots were quite generally used some time ago before the advance in price of this material. Its advantage is its light weight and consequent small heat consumption. Its disadvantages are its high price and the comparatively few shapes in which it can be secured. Some companies manufacture their own annealing boxes from wrought steel, riveting or welding them together. Some of these are said to give satisfaction in extreme temperatures, but not under general conditions. Wrought-steel riveted or

welded pots for cyanide, chloride or lead conditions have never been successful owing to leakage.

By "trick" materials, the author means products misrepresented by their makers or sold under a trade name which does not correctly indicate their nature. Alloys for heat-resisting purposes are a new development and may be said to be used in their infancy.

The latest development in the alloy field is a special nickel-chromium alloy, the analysis of which the author is not yet authorized to divulge. This material differs from nickel-chromium alloys on the market in that it retains many of the physical characteristics of the cold metal at a temperature of 2,800 deg. fahr. and rings like a bell when struck with a hammer at this temperature. This new alloy is known as Q-alloy, grade X.

The only true scale of value by which a user can judge most competitive production materials consumed in service is by comparing their life under service conditions with their initial cost, and determining how many units of service each renders per dollar investment. In computing pot and box cost a unit is a heat-hour, which is an hour in the furnace under heat. Cost per heat-hour is arrived at by dividing the number of heat-hours received into the initial cost of the pot or box; for instance, if a cast-iron box weighing 100 lb. and cost 5 cents per lb. runs 100 heat-hours, the cost is 5 cents per hour. A steel box at 12 cents per lb. should run at least 300 hours under the same conditions, making a cost to the user of 4 cents per heat-hour. Under certain circumstances parallel to this Q-alloy has been known to run 7,000 hours, making a cost to the user of 2 cents per heat-hour. Where an alloy affords a saving in cost per heat-hour it minimizes warpage and allows a thinner section to be used, thereby saving fuel in heating the box and its contents.

Thousands of tons of metal per annum are being consumed in the fires of heat-treating furnaces. This metal is paid for by companies every one of which could use the money so expended to the betterment of their product rather than writing it off in the profit-and-loss column and passing the tariff on to the ultimate consumer. American industry quite frequently puts up with undue waste to obtain production and perhaps the greatest waste in the metal-working industries, which can be directly attributed to ignorance and neglect, is the waste of metal consumed in the heat-treating processes. This waste can never be entirely eliminated, but it may be greatly reduced.—*The Iron Age*, Vol. 105, No. 11, March 11, 1920, pp. 729-731.

Progress in Mining and Metallurgy

Abstracts of Paper to be Presented at the Lake Superior Meeting, August, 1920

Prepared Under the Auspices of the American Institute of Mining and Metallurgical Engineers

DETERMINATION OF PORE SPACE OF OIL AND GAS SANDS.

By A. F. Melcher, M.S., Washington, D. C.

A progress report on an investigation of the physical factors of oil and gas and especially of their sands, such as pore space, size of pores or permeability, retentivity, viscosity of the oil, temperature, pressure, thickness and area of the pay sand, water relations, and capillarity. The purpose is to determine as many of these physical factors as possible, and to ascertain the relations existing, directly or indirectly, between these physical factors and the production of oil and gas. As yet only pore space and size of grains of pay sands have been investigated, although an apparatus has been designed to determine the permeability of a sand to oil, water, or gas under definite drops of pressure between the entrance face and exit face of the sample.

In selecting a method for the determination of pore space, two objects were kept in mind: First, the method must not only be sufficiently accurate to be of a truly scientific nature but must also be rapid enough to justify its commercial use. Second, the method, to have as large a range as possible, must permit the determination of pore space of many types of samples of different composition and structure, with great range of size.

Conclusions are as follows: A method has been established that will determine the pore space of very small fragments of oil and gas sands and determine the pore space accurately. None of the pay sands in which oil was found, if the pore space was less than 10.5 per cent, were producing sands. A study of samples suggests the conclusion that production is dependent on both pore space and size of grains, other factors being equal.

CHARPY IMPACT TEST AS APPLIED TO ALUMINUM ALLOYS.

By E. H. Dix, Jr., M. E., M. M. E., Cleveland, Ohio.

The success of the Charpy impact test in the steel industry has led to investigation of its possible application to aluminum and its alloys. Results of a few preliminary tests made at the Lynite Laboratories of the Aluminum Manufactures, Inc., are given. Slow-bending tests were made duplicating the arrangement of the impact machine, on both notched and unnotched specimens of a series of copper-aluminum alloys.

Results are summarized as follows: The Charpy impact resistance of copper-aluminum alloys decreases with increase in copper content, within the limit of these experiments (12 per cent copper).

No direct relation has been discovered between the Charpy impact resistance and the more common physical properties. However, in general, for this series of alloys the impact resistance decreases as the yield point, tensile strength and hardness increase and the impact value follows more nearly the elongation than the "product of tensile strength by elongation," as is often stated.

The notch effect is very much less pronounced in this series of alloys than in steel. The ratio of unnotched to the notched resistance in the Charpy test varies from 2.4 to 4.8, the notched bar having one-half the breaking area of the unnotched. For steel bars having equal breaking areas, the unnotched bar offers four to five times as much resistance as the notched bar. The notched specimen was the same as used in these experiments, but the unnotched was of the shape that would be obtained by planning a notched bar to the root of the notch.

The slow-bending tests give the same order of results as the Charpy impact, but the ratio of energy absorbed in the slow-bending test to that of the Charpy test varies from 0.27 to 1.02. Captain Philpot of England has reported that for steel this ratio is so nearly constant that he was led to the following conclusion: "The notched bar test made in a pendulum testing machine is not essentially an impact test." The experiments reported on in this paper do not justify such a conclusion for these copper-aluminum alloys.

The ratio of maximum load of the unnotched bar to maximum load of the notched bar in the slow-bending test is very interesting. Since the strength of a beam varies as the square of its depth, the maximum load of the unnotched bar should be four times that of the notched bar if the notched bar were not further weakened by the "notch effect." This

ratio varies from 2.73 for pure aluminum to 4.44 for the 12 per cent alloy. This shows that the notch not only does not weaken pure aluminum but rather enables it to stand a proportionally higher load. For the 12 per cent copper alloy, the weakening effect is small.

These results indicate that the Charpy impact test is a satisfactory test for aluminum alloys. When making this statement, the author fully realizes the danger of judging a material by its Charpy impact value without full consideration of the other physical properties. For instance, we must learn the proper Charpy figure combined with a given tensile strength and elongation that will give the most satisfactory shock-resisting aluminum alloy, just as the steel crankshaft manufacturer now knows the proper combination of Charpy impact value and yield-point strength that will give the most satisfactory service.

NITROGEN IN STEEL, AND THE EROSION OF GUNS.

By H. E. WHEELER, C.Ch.E., Chicago, Ill.

THE work described was carried out during 1917 and 1918 at the testing laboratory of Watertown Arsenal at the instigation of the Nitrate Division and later with the concurrence of the Cannon Section of the Ordnance Department, U. S. A. The experiments follow three principal lines of work: First, the effect of nitrogen under pressure on steel containers of various compositions at a red heat; second, the effect of decomposing ammonia on various alloy steels, iron and non-ferrous alloys; third, a new theory of the erosion of guns in respect to the effect of nitrogen in steel.

In the Haber process for the manufacture of ammonia from its elements, it is necessary to have nitrogen and hydrogen of 1500 lb. per sq. in. (105.5 kg. per sq. cm.) at a temperature of 500 to 600°C. The steel containers for these gases gave trouble by failing without apparent cause.

When the General Chemical Co. began to develop its method for the production of ammonia, it experienced the same difficulty and, knowing that the Haber process had solved the difficulty by the use of alloy steels, it made several small steel bottles of different compositions and kept them filled with these gases at this pressure and temperature until they failed. Four of these steel bottles were sent to this laboratory for investigation; they were a plain carbon-steel forging, a nickel-steel forging, a chrome-vanadium steel forging and a chrome steel-forging. The time of service was as follows: plain carbon steel, 4 mo.; nickel steel, 6 mo.; chrome-vanadium steel, over 2 yr.; chrome steel, 4 mo. When these containers were cut open and the cross-section surface polished, they showed an inside zone with a different luster from the rest of the metal. Upon etching, this zone was almost unaffected while the rest of the steel etched normally.

A few preliminary experiments on alloy steels indicated that a stream of ammonia passed over them for a long period of time, at about 650°C., gave an effect very similar to that observed in the cylinders described. High-pressure experiments with molecular nitrogen are difficult, dangerous, and take a great deal of time, so it was thought that a study of the effect of nascent nitrogen on various steels might throw some light on their general behavior and be a good method of elimination.

EROSION OF GUNS.

A study of the data on erosion shows that it has been customary to treat a comparatively small number of experiments with an intensive study of each, rather than to take the salient features from a larger number of experiments. The opportunity to take the latter course was presented during the war but, so far as the writer has been able to find out, no new facts regarding erosion were discovered by any of the governments participating. It is surprising to find that while almost all metals have been experimented with in so-called erosion experiments, only a very few have actually been tried in a gun; and even these have been tried only in a hit-and-miss fashion.

For this paper, erosion will be defined as the enlargement of the bore and obliteration of the rifling from any cause. Some of these causes are: The eccentric path taken by the projectile and the consequent pounding; the whip or vibration of long guns; the muzzle droop of long guns; mechanical wear or abrasion, from the passing of the projectile, gases, or unburned powder, etc.; protrusion of liners and consequent loss of metal within the bore; swelling of barrel (in small arms) due to lowering of elastic limit; cracking of bore surface due to the formation of a hard layer of low ductility. Only this last feature of erosion is dealt with.

To describe it briefly, even after the first few rounds, there is a noticeable hardening of the surface, which is selective in its formation. The microscope reveals it as a layer that remains bright on etching and exhibits no structure. The formation follows the driving side of the lands, preferentially, and eventually the entire land and groove and even the powder chamber and forcing cone are affected. The formation on the bearing surface of the land extends much farther down the bore than on any other point of the circumference. This layer is characterized by hardness and especially by its low ductility, so that it no sooner forms than it develops a network of fine hair-like cracks which make a characteristic pattern, the largest being in a plane perpendicular or parallel to the axis of the bore. The enlargement of these cracks, and the consequent roughening of the bore, is generally admitted to be one of the chief determining factors in the life of guns of large calibers.

STABILITY OF VARIOUS HICKORIES FOR VEHICLE MANUFACTURE.

THE principal species of hickory are divided botanically into two groups, true hickories and pecan hickories. True hickories include shellbark, shagbark, mockernut, and pignut or black hickories. Pecans include bitternut, nutmeg, pecan, and water hickories.

The chief difference between true and pecan hickory, as shown by tests at the Forest Products Laboratory, is in toughness or shock-resisting ability. This is the property which is so valuable in wood handles and vehicle parts. In this property true hickories are far superior to the pecans.

The strength properties of pecan are somewhat in excess of those of oak or maple, and for such articles as handles and buggy spokes, carefully selected pecan is probably to be preferred to either of these two woods. In heavy wagon parts, such as axles, spokes and felloes, maple and oak are reputed to stay in place better than hickory. Except in case of extreme shortage of maple, true hickory and oak it would probably be inexpedient to use pecan hickory for these heavy parts.

The sapwood or white wood of hickory, which is usually preferred by the trade, is the better wood in young, thrifty trees; but in over-mature trees it is inferior to the heartwood. A red color does not necessarily make sound hickory unsuitable for vehicle stock.

A more useful criterion than color is the proportion of summerwood, or nonporous wood, in the annual growth rings. In hickory stock intended for the more exacting uses, the nonporous wood should form at least one-half and preferably three-quarters of the annual ring; and the remaining part should contain very few pores. A further precaution to be observed is that the nonporous part of the annual ring should be hard and flinty.

The best criterion of the strength properties of either true or pecan hickory is the weight of a cubic foot of the dry wood. This weight should not be more than 10 per cent below the average for true hickory; or not less than 45 pounds per cubic foot of oven-dry wood.